(Re)defining nurse and patient roles in routine postoperative neurosurgical care: empowering autonomy and strengthening collaborative roles

Nollen, J.M.

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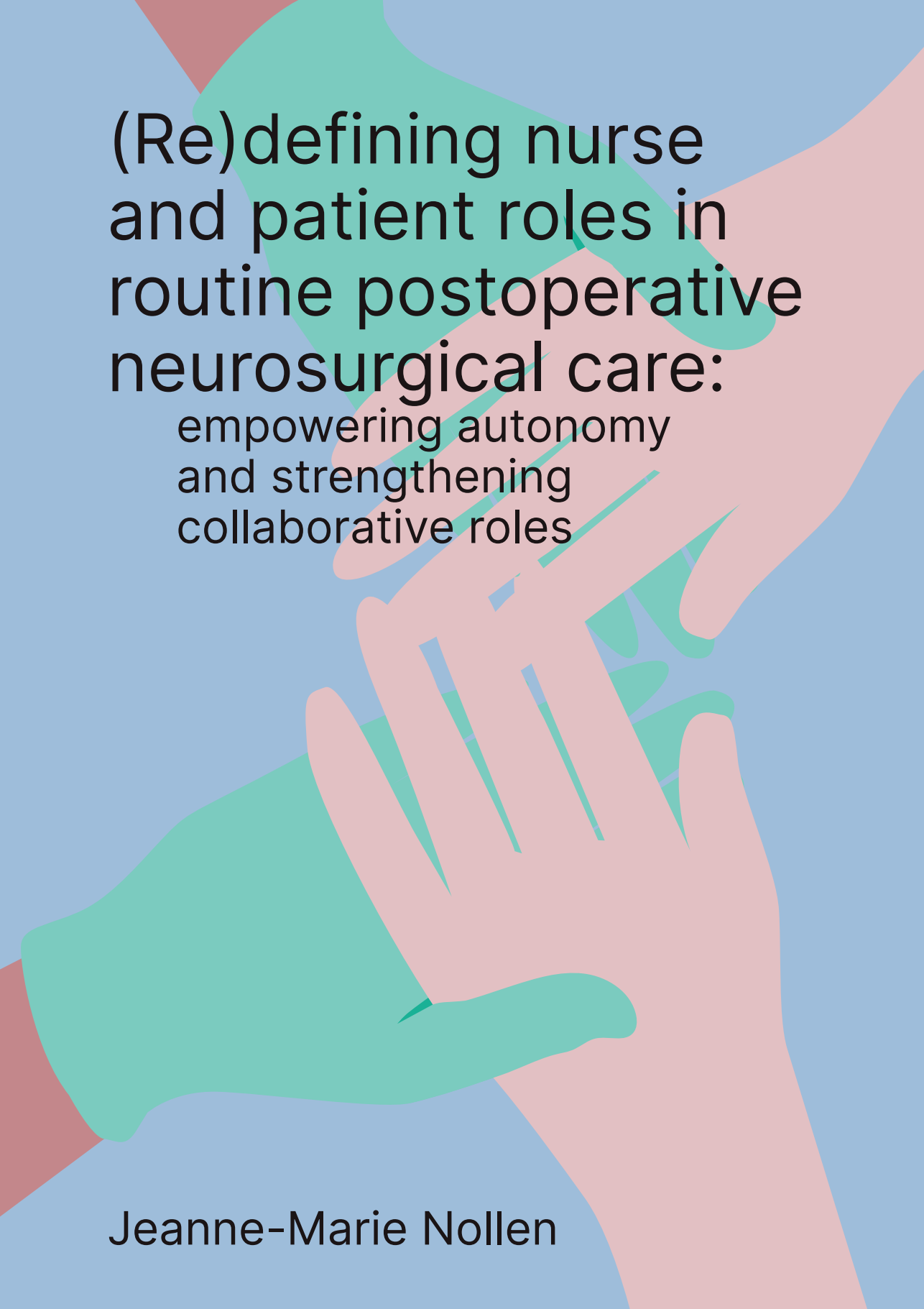

Jeanne-Marie Nollen

Stellingen behorend bij het proefschrift
‘(Re)defining nurse and patient roles in routine postoperative neurosurgical care: empowering autonomy and strengthening collaborative roles’

1. Early removal of indwelling urinary catheters after neurosurgical procedures significantly accelerates mobilization and shortens hospital stay. (This thesis)
2. Nurses’ fear of re-catheterization often outweighs patient discomfort and undermines evidence-based decision-making. (This thesis)
3. The absence of shared decision-making in catheter removal is less a matter of logistics and more a reflection of ingrained hierarchical culture. (This thesis)
4. Patients are more capable of monitoring their fluid balance than nurses and physicians generally assume. (This thesis)
5. The lack of standardized definitions for postoperative complications, such as urinary tract infections and urinary retention, hampers comparability and quality improvement across studies. (This thesis)
6. The successful implementation of nurse-led catheter removal protocols requires not only guidelines but also behavioral support interventions. (Based on Kitson et al. – The PARIHS framework: a framework for guiding the implementation of evidence-based practice. J Adv Nurs, 2008; This thesis)
7. *“You can check out any time you like, but you can never leave.”* The paradox of being physically mobile yet still confined to the ward. (Study patient’s remark; The Eagles)
8. Patients may face discomfort, dependency and confusion in early postoperative care. But supporting them through this phase is essential for true recovery. (Based on Antoine de Saint-Exupéry)
9. Nursing autonomy is an underrecognized determinant of postoperative patient outcomes. (Yuk & Yu – The effect of professional autonomy and nursing work environment on nurses’ patient safety activities. J Nurs Manag, 2023)
10. Clinical studies on urinary catheter management insufficiently incorporate patient-reported outcome measures (PROMs). (Based on Porter et al. – What is value in health care? N Engl J Med, 2010)
11. Patients are still too often treated as passive recipients of care, rather than as active partners in recovery. (Based on Epstein & Street – The values and value of patient-centered care. Ann Fam Med, 2011)
12. *“Alles beter dan een katheter”* klinkt misschien als cabaret, maar raakt de kern van het patiëntperspectief op postoperatieve zorg. (With permission of Jochem Myjer, based on his experience)

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Chapter 1
General introduction and thesis outline

Clinical importance and history of urine monitoring
Urine monitoring has been a fundamental aspect of medical practice since ancient times, serving as a critical indicator of a patient's fluid balance, renal function, and overall hemodynamic status (1). This practice extends beyond mere measurement of urine output; it encompasses the detailed analysis of urine composition, such as specific gravity, electrolyte levels, and the presence of proteins or glucose, which provide essential insights into a patient's metabolic and renal function (2).

A widely utilized technique for urine monitoring is the use of urinary catheters, with evidence of their application dating back to approximately 3000 BCE. Early urinary catheters were constructed from primitive materials such as hollow reeds and metal tubes (3). Over centuries, advancements in urinary catheter technology included the 18th-century introduction of silver catheters and the 19th-century adoption of rubber catheters, each representing a significant step forward in urological care (4). The most transformative development in urinary catheterization emerged in the 1930s when Frederic Foley invented his groundbreaking catheter design. The Foley catheter's innovative balloon mechanism, which prevents the device from becoming dislodged, quickly established itself as the gold standard in catheterization procedures and continues to maintain this position in modern clinical practice (5). Within the broader field of urinary catheterization, two distinct categories of devices serve different clinical needs. The first category consists of indwelling urinary catheters (IDUCs), commonly known as Foley catheters, which provide continuous, long-term drainage solutions. The second category encompasses intermittent catheters, which are designed for single-use, short-term drainage sessions that patients or healthcare providers repeat as necessary based on individual medical requirements (6).

Prevalence of urinary catheterization
IDUCs are widely used in various healthcare settings, particularly hospitals, with studies indicating that approximately 15%–25% of hospitalized patients receive an IDUC during their stay (7). The use of IDUCs is even more prevalent in surgical care, where over 80% of patients require catheterization, particularly during or after major procedures (8). Obtaining precise and current numbers on the use of intermittent catheterization in hospitals is more challenging, as the data is often less widely reported than that for IDUCs. However, existing literature suggests that intermittent catheterization is employed in approximately 10%–20% of hospitalized patients (6).

Complications of urinary catheterization
Although urinary catheterization is essential in certain clinical scenarios, it carries significant risks. The most common complication is catheter-associated urinary tract infection, which accounts for approximately 9% of all healthcare-acquired infections (9). The daily risk of developing this type of infection ranges from 3% to 7% with an IDUC (10). These infections not only increase patient morbidity but also lead to higher healthcare costs, extended hospital stays, and, in severe cases, mortality (11). Additionally, urinary catheters can cause a range of other complications, including urethral trauma, bladder spasms, and the formation of bladder stones (12). The presence of an IDUC can also hinder early mobilization, increase the risk of deep vein thrombosis, and contribute to patient discomfort and psychosocial distress (13).

Urine monitoring in the postoperative phase
The role of urine monitoring and urinary catheter use plays a critical role in hospital care,

with particular significance in the management of neurosurgical patients. This importance becomes especially evident when managing two specific groups of patients. The first group consists of those undergoing transsphenoidal pituitary surgery, while the second includes patients undergoing spinal fusion procedures, also known as spondylodesis. Each of these patient populations presents distinct requirements for precise urine monitoring, reflecting the unique challenges and complications that can arise during their respective surgical procedures and recovery periods. Transsphenoidal pituitary surgery, which is performed to remove pituitary tumors, carries a significant risk of endocrine disturbances due to manipulation of the pituitary gland, which regulates various hormonal functions.

During the postoperative phase, healthcare providers, particularly nurses, must carefully monitor fluid balance to detect a serious potential complication known as Arginine Vasopressin Deficiency (AVP-D) (14). This condition manifests through the excretion of large volumes of dilute urine, making vigilant monitoring of both urine output and specific gravity crucial components of postoperative care (15). Through such careful observation, medical teams can ensure timely intervention when necessary and support optimal patient recovery. Though not as extensively studied, there are indications that patients undergoing spinal fusion surgery may have a heightened risk of developing postoperative urinary retention due to the possibility of neurological impairment (16). Consequently, urine monitoring is vital to prevent bladder overdistention (17). Furthermore, postoperative urine output monitoring is essential for accurately assessing a patient's fluid balance and for the early detection of potential complications, including renal dysfunction, or developing infections (18).

The routine use of urinary catheters in these clinical scenarios has, however, been increasingly critiqued due to concerns over associated risks and the necessity of such interventions. Research indicates that up to half of the urinary catheters placed in hospitals may lack an appropriate clinical indication, underscoring the need for alternative urine monitoring methods that can minimize or eliminate unnecessary catheterization (19). Moreover, evidence suggests that, particularly in cases of short-duration surgeries (< three hours) with minimal postoperative mobility restrictions, the risks associated with urinary catheterization may outweigh its benefits (20). Despite this, there remains a lack of standardized protocols regarding the insertion and removal of urinary catheters, leading to variability in practice and potentially unnecessary catheter use. This variability highlights the need for clearer guidelines and more individualized patient care strategies to mitigate the risks associated with prolonged urinary catheter use (21).

Role of nurses and patients

Given the importance of urinary monitoring and the significant risks associated with urinary catheterization, optimizing its use in clinical practice is crucial (22). Achieving optimization requires a multifaceted approach, including the development of clearer clinical guidelines, the implementation of alternative urine monitoring methods, and the empowerment of both nurses and patients in the decision-making process (23). Nurses have historically played a central role in urine monitoring and urinary catheter management, from insertion to maintenance and removal (24). In the modern healthcare setting, their responsibilities have expanded to educating patients about the risks associated with catheterization and ensuring adherence to best practices to prevent complications, such as urinary tract infections (25). Traditionally, the decision to insert a urinary catheter has been made by physicians. However, there is growing recognition of the impor-

tance of involving nurses in this decision-making process due to their clinical expertise and close contact with patients (26). Granting nurses greater autonomy in managing urinary catheters, including making decisions about their placement and removal, could lead to more timely and appropriate interventions, thereby reducing complications and enhancing patient comfort (27).

This expansion of nursing roles aligns with the increasing emphasis on patient participation in their own care. Engaging patients as active stakeholders in decision-making processes has been shown to improve health outcomes, increase patient satisfaction, and optimize healthcare resource use (28). Despite the shift towards patient-centered care, there remains a significant gap in effectively involving patients in urine monitoring and decisions regarding urinary catheter use, as research in this area remains relatively limited.

Conclusion
The evolving roles of nurses and patients in postoperative care present both challenges and opportunities. By redefining these roles and fostering a collaborative approach to care, healthcare systems can improve patient outcomes, enhance the efficiency of care delivery, and create a more patient-centered healthcare environment. This dissertation aims to explore these themes in the context of neurosurgical care, focusing on urinary monitoring and the management of urinary catheters as key areas where expanded nursing roles and patient participation can make a significant impact. Through a series of studies and a review, this dissertation will provide valuable insights into the factors influencing urinary monitoring, urinary catheter management decisions, the experiences and perspectives of patients, and the effectiveness of strategies aimed at optimizing postoperative care.

Aims and Thesis Outline
The objective of this thesis is to optimize urine monitoring and urinary catheterization after transsphenoidal pituitary and spondylodesis surgery, with a focus on reducing postoperative complications and enhancing the roles of both nurses and patients in care management. For this purpose, the following specific research questions were formulated:

1. How do clinical factors, healthcare professionals' and patients' experiences, and existing literature inform optimal strategies for IDUC management after transsphenoidal pituitary and general surgery?
2. What is the role of patient involvement in postoperative care, specifically in the context of urinary monitoring and the detection of AVP-D?
3. How effective are de-implementation strategies in reducing unnecessary urinary catheter use and associated complications after transsphenoidal pituitary and spondylodesis surgeries?

The first chapters of this dissertation delve into various aspects of IDUC management. These sections provide a comprehensive overview of insights from healthcare professionals, patient perspectives, and a systematic review of the literature.

Chapter 2 focuses on exploring the complex decision-making processes behind the removal of IDUCs after transsphenoidal pituitary surgery. This chapter aims to provide valuable insights from healthcare professionals regarding the factors influencing these critical decisions. **Chapter 3** presents a qualitative study capturing patient perspectives on the use of IDUCs and the management of fluid balances after transsphenoidal pituitary surgery. This chapter sheds light on the experiences and views of patients,

with the goal of enhancing postoperative care. **Chapter 4** offers a systematic review of the impact of early postoperative IDUC removal after a broad range of operations. This chapter synthesizes existing research to evaluate the optimal timing for IDUC removal and its effects on patient outcomes.

The subsequent chapters shift focus towards strategies aimed at improving perioperative care and reducing complications associated with urinary catheter use in both pituitary and spondylodesis surgeries. **Chapter 5**, outlines a mixed-methods multicentre study protocol for the de-implementation of urinary catheters during surgery and on the ward. This chapter aims to assess how reducing urinary catheter use impacts patient outcomes, contributing to safer and more effective perioperative care. **Chapter 6** reports the implementation of a standardized protocol for urinary catheter placement in a multicentre before-and-after study. This chapter evaluates the safety, feasibility, and outcomes of this protocol, aiming to improve postoperative care and reduce unnecessary catheterizations.

Finally, the dissertation addresses the importance of patient empowerment and participation in managing postoperative AVP-D after transsphenoidal pituitary surgery. **Chapter 7** focuses on patient involvement by addressing how simplifying specific gravity measurements can empower patients to take an active role in preventing AVP-D. This chapter highlights the importance of patient participation in collaborating with nurses.

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Chapter 2
Decision-making around removal of indwelling urinary catheters after pituitary surgery

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Abstract

Background
Diabetes insipidus (DI) is a common complication post-pituitary surgery, causing significant health issues if untreated. As part of the diagnostic process, accurate urinary output monitoring via indwelling urinary catheters (IDUCs) is essential, despite risks such as urinary tract infections and hindered recovery. Research on IDUC removal post-pituitary surgery remains scarce.

Aim
To explore healthcare professionals' perspectives on IDUC management following pituitary surgery.

Methods
Employing a qualitative design, semi-structured interviews were conducted with 15 professionals in a Dutch academic hospital's neurosurgical ward.

Findings
Four theme's emerged: concerns about missing DI, patient-nurse dynamics, workload management, and lack of shared decision making.

Conclusion
The findings underscore the need to balance clinical needs with patient care efficiency. There is a need for evidence-based guidelines and a multidisciplinary approach to optimise IDUC management, given the importance of patient-centred care and shared decision-making.

Background

Diabetes insipidus (DI) is a complication following pituitary gland surgery. Various definitions are used across studies, which means that reported rates vary, but a large systematic review found the rate following transsphenoidal pituitary surgery to be 17% (1). DI is caused by a shortage of the antidiuretic hormone and results in polyuria and compensatory polydipsia in the first 12–24 hours after surgery (2). If left untreated, DI can lead to hypovolemia, dehydration and electrolyte imbalances, which subsequently can lead to multi-system organ failure (3). The diagnosis of DI is based on clinical and biochemical findings, with the first step in the diagnostic process being the presence of polyuria and polydipsia, which can be detected by monitoring fluid balances (4).

The use of continuous bladder drainage through indwelling urinary catheters (IDUCs) has become standard practice after pituitary surgery to ensure accurate monitoring of urinary output (5). This method not only minimizes the loss of urinary output but also enhances the accuracy of monitoring, thereby enabling nursing staff to conduct precise measurements of urinary output (6-8).

Despite their utility, IDUCs are associated with an increased incidence of urinary tract infections (UTIs), carrying a 3-7% chance of UTI for each additional day the catheter is retained (9). UTIs can prolong hospital stays, amplify morbidity and mortality rates, and incur significant additional costs (10). In addition, IDUCs may hinder patient mobility and daily activities, impacting postoperative recovery (11).

Extensive research, especially within intensive care and emergency department settings, has highlighted the importance of early IDUC removal, ideally within 24-hours postoperative, to reduce infection risks and enhance patient recovery (12-14). Despite this, the specific challenges of IDUC removal after pituitary surgery - particularly in managing the increased risk of postoperative DI - have not been thoroughly researched. Given the complexity introduced by DI, the perspectives of healthcare professionals (HCPs) are crucial for understanding postoperative care in this context.

Aims

Our study aims to explore the considerations and experiences of HCPs, who are central in the decision-making process regarding IDUC management on the first postoperative day for patients undergoing pituitary gland tumour surgery.

Methods

Study design

This study used a qualitative design, conducting semi-structured interviews to explore the experiences and considerations of health professionals involved in postoperative care for pituitary patients.

Sample and setting

The research was conducted in a neurosurgical ward at a university hospital in the Netherlands. The researchers adopted purposive sampling to select participants, aiming for a rich diversity of perspectives. Out of 17 professionals approached, 15 participated. This group included one neurosurgeon, four neurosurgical residents, one physician assistant (PA), and nine nurses. A conscious choice was made to include a larger number of nurses compared with other health professionals, recognizing their critical role in carrying out postoperative care.

Participants were selected based on their direct involvement in the care of pituitary patients, requiring a minimum of 3 months of experience in the neurosurgical department to ensure familiarity with the specificities of pituitary care. Exclusion criteria were designed to prevent potential bias, excluding any health professional who had closely collaborated with the primary researcher within the past 6 months or those in more temporary positions such as ‘flex pools’ or students.

Data collection

Data were collected through semi-structured interviews. The interview guide (Table 1) was structured around the Attitudes, Social influence, and Self-efficacy (ASE) model, augmented with expert knowledge (15). Initial insights were obtained from two pilot interviews - one with a resident and another with a nurse, both from different wards within the university hospital. Feedback from these sessions led to refinements to the interview guide, specifically to enhance questions on patient participation and to clarify the concept of intuition. Subsequent adjustments were made following input from the neurosurgeon and a nurse. Interviews were conducted face to face in Dutch and audio-recorded, scheduled between April 2019 and June 2020 based on participant availability, and lasted 30–60 minutes.

Table 1: Interview topics

Interview topics
Opening question How would you describe the postoperative phase after pituitary gland tumour surgery? – Care and specific points of attention – Medical file management*
Attitude How do you view the timing of indwelling urinary catheters (IDUC) removal in pituitary patients? – Diabetes insipidus? – Patient comfort – Severity of illness – Fluid balance – Nurses' position – Guidelines – Policy made by physician – Ability to make decisions – Timing – Patient participation*
Self-efficacy What role does your intuition play in the decision to remove an IDUC in pituitary patients? – Knowledge – Experience – Insight – Norms and values – Inner feelings*
Social norm To what extent do the written and unwritten rules on the ward influence IDUC removal in pituitary patients? – Role of the protocol – Role of physician policy – Shared/individual decision making – Being able to discuss rules with others – Integrity/adherence to work-related norms and values – Doubts about guideline/policy/decision – Experience in other workplaces*
*These points were added during the research process

Data analysis

Thematic analysis was performed on the transcribed interviews (16). Two researchers independently engaged in a rigorous coding process, identifying initial codes, and subsequently organizing them into themes and subthemes (17). An iterative approach was used in which data collection and analysis occurred simultaneously (18). After conducting 15 interviews, data saturation was reached (19). Findings were summarized and shared with participants for validation. A detailed logbook documented each step of the research. ATLAS.ti software facilitated the organization and analysis of data (20). The analysis was performed in Dutch, and quotes were later translated into English by a native speaker.

Ethical considerations

All procedures complied with relevant laws and guidelines, approved by the hospital's Medical Ethics Committee (approval number N19.015). Participant consent was obtained; confidentiality was ensured.

Findings

Participants' demographics are presented in Table 2. Four themes emerged: Concerns about missing DI, patient–nurse dynamics, workload management, and lack of shared decision making. Each theme is divided into subthemes and quotations are included in the text.

Table 2: Participant demographics

	N = 15 (%)
Sex	
Male	5 (33.3)
Female	10 (66.6)
Age, years - mean (SD)	48.2 (16.3)
20 – 29	9 (60)
30 – 39	3 (20)
40 – 49	0 (0)
50 – 59	3 (20)
Profession - distribution	3.5 (1.2)
Nurse	9 (60)
Resident	4 (26.7)
Physician assistant	1 (6.7)
Neurosurgeon	1 (6.7)
Work experience, year	
< 1	3 (20)
1 – 5	6 (40)
6 – 10	4 (26.7)
> 10	2 (13.3)

Theme 1: Concerns about missing DI

Health professionals unanimously expressed concern over the potential for missing a diagnosis of DI if the IDUC were removed prematurely.

Monitoring accuracy

The physician assistant explained the reliance on IDUCs for precise monitoring, especially in uncertain cases of DI: *'If I am not sure if the patient is going to develop diabetes insipidus, I would prefer to keep the catheter in place because I feel that it is beneficial for the accuracy of the fluid balance'*. Practical issues such as incontinence, misuse of bedpan or urinal, and the lack of a scale for weighing incontinence material were cited as barriers to effective fluid balance monitoring without an IDUC. Some nurses voiced that these challenges made non-IDUC monitoring infeasible.

IDUC necessity

The necessity of using IDUCs for fluid balance monitoring was debated. A neurosurgeon, one resident, and one nurse showed a preference for non-invasive monitoring methods. The neurosurgeon mentioned: *'In the end, the patient needs to go home, and there they don't have a catheter either and I think if the patient is compos mentis, he should be able to monitor his fluid balance in the hospital'.* This reflects a perception that, when mentally capable, the patient has the ability to manage without an IDUC. Despite recognising IDUCs as a risk factor for delirium, delirium itself was considered by several participants as a valid reason for using IDUCs due to the potential loss of urinary output.

Theme 2: Patient–nurse dynamics
This theme highlights how patient-specific factors and nurse perceptions shape clinical actions.

Gender and clinical factors
All participants thought that clinical deterioration and a history of urinary tract abnormalities warrant cautious consideration regarding IDUC management. Gender differences and physical abilities were also important factors. One nurse explained: *'Gender and physical ability play crucial roles. It's particularly strenuous for heavy female patients who need to use a bedpan, making it a physically demanding task for both the patient and me'.* All nurses and the neurosurgeon agreed that gender differences significantly influence IDUC removal decisions, noting the ease with which male patients use a urinal compared with the challenges female patients encounter with bedpans.

Physical and psychological effects
Most nurses reported that the presence of an IDUC limits physical mobility and imposes a psychological burden, manifesting as shame or fear. Some nurses observed a tendency to delay IDUC removal in patients exhibiting anxiety about mobility. The neurosurgeon and some nurses viewed IDUC-caused discomfort as a reason for removal, despite the perception that medication can manage pain. One nurse stated: *'If the patient says the catheter hurts, I can give him pain medication. If I feel that [it] is better to retain the IDUC to monitor DI, I insist on keeping it, given my expertise and experience'.'* The neurosurgeon, one resident and most nurses considered the occasional 24-hour postoperative mobility restriction as a valid reason for delaying IDUC removal, attributing this to the patient's inability to independently use the bathroom during that period.

Empathic care
Participants highlighted their perception that nurses, distinguished by their empathy, patience and nurturing nature, tended to place greater emphasis on patient comfort, which may lead to postponed IDUC removal.

Theme 3: Workload management
This theme reflects on how IDUCs, although facilitating patient care, also pose challenges related to workload management and adherence to protocols.

Improving efficiency
Nurses unanimously acknowledged the role of IDUCs in optimising their workload by facilitating strict adherence to fluid-balance monitoring schedules. One nurse vividly described the laborious task of managing patients without an IDUC: *'Whenever a patient needs to urinate, it requires providing them with a urinal or bedpan and subsequently collecting it, which significantly increases my workload. Walking extensive distances becomes a daily routine. In contrast, having a catheter in place simplifies this process, as it only necessitates emptying it every three hours'.*

Scheduling challenges
Nurses expressed concerns over the hospital protocol that mandates early morning IDUC removal, often leading to practical dilemmas. The prescribed timing for IDUC removal at 6am was highlighted as a point of disagreement, primarily due to the difficulties in co-ordinating with medical staff and the potential discomfort caused to patients. One nurse shared: *'No, I won't call the resident at 6:00 to ask if I can remove the cathe-*

ter. In my experience, the resident is not happy with me if I wake him up for this. Then I just leave the catheter. I just postpone removal and the dayshift can fix it'. This illustrates the reluctance to adhere to the set timing due to anticipated negative responses from medical colleagues.

To address the challenges associated with the 6am removal, alternative strategies such as late-night removal or flexible scheduling were considered. Yet, some nurses expressed doubts about the feasibility of changing established practices within their ward: *'I am not sure if [it] is possible to change the time of removing the catheter. We don't look at the protocol, we just do it how we have done it for years'.*

Theme 4: Lack of shared decision-making
Participants expressed divergent views on who had the authority to decide on IDUC removal, influenced by their interpretation of professional roles and responsibilities.

Role clarity and autonomy
Nurses displayed confidence in their judgment regarding IDUC management, valuing their autonomy within the collaborative care team. One nurse explained this balance: *'I think I have enough experience to make the decision to remove a catheter on my own, without discussing with a resident first'. Contrastingly, medical staff, including the neurosurgeon, advocated for a hierarchical decision process, emphasising their ultimate responsibility: 'The resident can decide, of course. I think it is up to the medical staff to decide if the catheter can be removed since we are ultimately responsible for the patient'.*

The division of roles brings to light the central issue of decision-making authority, as underscored by a resident's observation: *'I feel that nurses are the link between residents and patients. The residents will never actually remove a catheter so if we ask them [the nurses] to remove it and they don't do it, maybe that is a sign that we should try to understand their reasons not to do so more ... because now I don't understand it'.*

Conflict and collaboration
Divergent perspectives often lead to conflict, especially when the patient's discharge is at stake. The comment from a resident illustrates this: *'In some cases, I experience it [nurses not obeying the orders of residents] as a hindering factor on the speed of discharging patients. Sometimes, nurses just do whatever they want, without looking at the bigger picture. If the catheter is removed one day later than what could have been possible, it can take longer before the patient can go home'.*
Nurses, on their part, wanted residents to have more consideration regarding practicalities and patient readiness: *'Sometimes a resident orders me to remove the catheter without asking me if the patient is ready for it or if the timing is convenient for me. I feel like the resident does not always think about the consequences for the patient and the nurse if a patient, for example, is tired or has bedrest'.*

Shared decision-making
Opinions varied on the extent to which decisions about IDUC removal should be collaborative. Although some nurses advocated for increased patient involvement – 'IDUC removal should be a joint decision between residents, nurses, and patients' – some other nurses and residents preferred a more controlled approach by health professionals: *'I prefer having control over the situation, as overly involving patients in the decision-making process may not be beneficial. Patients should have the opportunity to*

focus on being patients, concentrating on their recovery'.
There is a consensus on the value of interdisciplinary discussions for facilitating timely removal decisions.

Discussion

This study explored health professionals' considerations in deciding to remove or retain IDUCs following pituitary tumour surgery, revealing decision-making processes shaped by concerns over diagnosing DI, patient characteristics, workload implication, and decision-making authority. These findings deepen our understanding of postoperative IDUC management, highlighting the balance between clinical judgement and practical considerations in a complex healthcare environment.

Concerns over accurately monitoring DI and ensuring patient safety prevailed, emphasizing the vital role of IDUCs. This aligns with previous studies that underscore the importance of precise monitoring in the immediate postoperative period (2, 21). Our findings suggest a need for clear, evidence-based guidelines that can support HCPs in making informed decisions about IDUC removal, potentially reducing the reliance on IDUCs for DI monitoring.

Divergent views on the authority for IDUC removal underscore a broader issue of role clarification within postoperative care teams, echoing observations on the overlap in perceived responsibilities (22). Implementing a nurse-driven protocol, as proposed in earlier research, could streamline this process, enhancing collaboration and improving patient outcomes (23, 24).

The study underscored the significance of IDUCs in enhancing nursing efficiency, reflecting findings from other studies (25). t is crucial, however, to balance these operational advantages with the well-being of patients, particularly considering the risks of UTI (10). Thus, optimizing postoperative care involves a comprehensive approach that equally prioritizes both nursing workflow and patient safety.

The findings of the present study reveal a gap in patient involvement in IDUC removal decisions, underscoring the need for more patient-centred care practices. Enhancing patient education on the risks and alternatives to IDUCs could empower patients and foster shared decision-making, aligning with recommendations for decision aid tools (26, 27).

Several issues associated with the 06:00 AM removal time, which resulted in postponed removal, became apparent. Existing literature offers no definitive guidance on the optimal timing for IDUC removal, with some studies advocating for removal at 06:00 AM while others favour midnight (28). Despite this lack of consensus, a common recommendation is to remove the IDUC as soon as possible after the operation (29).

Strengths and limitations

This study's interdisciplinary approach allowed for an examination of IDUC management following pituitary surgery, enhancing the depth and quality of insights despite its nurse-centric subject. A code-recode analysis by two researchers ensured thorough data evaluation. The study's narrow focus on a specific patient group and single hospital ward limits its generalisability, yet the findings offer valuable insights into specialised postoperative care dynamics.

Further research
Research should aim to find the optimal timing for IDUC removal using predictive modelling based on variables like surgery time, tumour type, and patient mobility, considering interdisciplinary input and patient care impact.

Conclusion
This research sheds light on the complex decision-making processes of health professionals regarding the retention or removal of IDUCs following pituitary surgery. With the findings highlighting the critical importance of accurate monitoring for DI and efficient postoperative care, the authors would advocate for clear, evidence-based guidelines to support these critical decisions. The findings emphasise the necessity of role clarification within care teams and the promotion of patient-centred approaches through enhanced education and shared decision-making. The authors would encourage interdisciplinary efforts to optimise care protocols and identify best practices for IDUC management.

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Chapter 3
Patient perspectives on indwelling urinary catheters and fluid balances after trans-sphenoidal pituitary surgery: a qualitative study

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Abstract

Objectives
To explore the perceptions and experiences of patients who underwent transsphenoidal pituitary gland and (para)sellar tumor surgery regarding IDUCs (indwelling urinary catheters) and the postoperative fluid balance.

Design
Qualitative study using semi-structured interviews based on the attitudes, social influence and self-efficacy model and expert knowledge.

Participants
Twelve patients who underwent transsphenoidal pituitary gland tumor surgery and received an IDUC during or after surgery.

Setting
One patient was interviewed in the endocrinology outpatient clinic and 11 patients were interviewed on the neurosurgery ward.

Results
Five major themes emerged: (1) conflicting information and preoperative expectations, (2) IDUCs perceived as patient-friendly during bedrest, particularly for women, (3) little room for patients' opinions, (4) physical and emotional limitations and (5) fluid balance causes confusion. Information regarding IDUC placement and fluid balance given to patients both pre- and postoperatively did not meet their expectations, which led to confusion and uncertainty. The IDUC was perceived as preferable if bedrest was mandatory, preferred particularly by women. Patient could not mobilize freely due to the IDUC and felt ashamed, judged by others and dependent on nurses.

Conclusions
This study provides insight into the challenges patients experience in relation to the IDUC and fluid balance. Perceptions on the necessity of an IDUC varied among patients and were influenced by both physical and emotional impediments. A clear, frequent and daily communication between healthcare professionals and patients to evaluate IDUC and fluid balance use is necessary to increase patient satisfaction.

Introduction

To evaluate hospital care and the corresponding processes, patients' perspectives play a crucial role as they offer information that goes beyond the scope of regular hospital staff evaluations (1).
Two frequently studied topics to gain insight in hospital care during the postoperative phase are indwelling urinary catheters (IDUCs) and fluid balances. While studies investigating fluid balances have focused primarily on accuracy and diagnostic value in critical care settings rather than focus on patient perspectives, patient experiences with and perceptions of IDUCs in the postoperative phase have been widely researched (2 – 4). Patients have connected IDUCs with both infectious-, including urinary tract infections (UTIs), and non-infectious problems, such as pain and discomfort (5). These studies focused on general surgical populations despite literature indicating that patients perspectives could be influenced by their specific illness and operation and that research

should therefore keep the individual needs and specific situations in mind (6).
One group of patients who are a useful source of information about IDUC and fluid balance experiences are patients who underwent transsphenoidal pituitary gland and (para) sellar tumor surgery. In the university hospital, IDUCs are not routinely placed during this surgery due to the relatively short operation time of 2-3 hours (7). Despite this policy, IDUCs are frequently inserted postoperatively at the neurosurgical ward.

Two potential postoperative complications influence IDUC placement and the necessity of monitoring the fluid balance in this specific population. First, pituitary patients are at risk of developing the electrolyte disorder diabetes insipidus (DI) (8). Accurate monitoring of the fluid balance, every 3-6 hours postoperatively, is essential for the early detection of DI as well as the consideration of desmopressin therapy, which is the primary pharmacological treatment (9). On the ward, nurses measure the urine volume in a urinal and patients use a personal fluid balance chart to register the fluid intake. As DI can occur in the 10 days following surgery, the fluid balance needs to be monitored after discharge (10). IDUCs can contribute to a reliable fluid balance and are convenient for nurses when monitoring the urinary output (11, 12).

Second, to prevent post-transsphenoidal cerebrospinal fluid leakage, bed rest, with elevation of the head of bed at 30° for 24-hours, is a frequently occurring postoperative instruction which could influence the patient's ability to urinate (13, 14). Bed rest is identified as a risk factor for a retention bladder, which is defined as the inability to urinate despite a full bladder (>500 ml) and can lead to complications including UTIs and stretched bladder muscles (15, 16). If a patient develops a retention bladder, IDUCs are the primary intervention (17).

Previous studies have explored pre- and post-surgery symptom burden of DI and established the need for support before, during and after hospital admission (18, 19). However, to the best of our knowledge, patient perspectives regarding IDUCs and monitoring the fluid balance have not been studied in this specific patient population and setting despite having a major impact during the acute postoperative phase. Consequently, this study aims to explore the perspectives and experiences of patients who underwent transsphenoidal pituitary gland and (para)sellar tumor surgery regarding IDUCs and fluid balances on a neurosurgical ward.

Methods

Study design

A qualitative study design was adopted which involved semi-structured interviews with patients who underwent transsphenoidal pituitary gland and (para)sellar tumor surgery to explore their perceptions and experiences regarding IDUCs and the postoperative fluid balance.

Setting and participants

The study was conducted in a 16-bed department of neurosurgery at a University Hospital in the Netherlands. Participants who underwent transsphenoidal pituitary gland and (para)sellar tumor surgery, received an IDUC in the peri- or postoperative period, and were aged >18 were approached face-to-face if they were admitted to the neurosurgical ward or by phone if they were discharged. Convenience sampling was used to approach 13 patients, 12 of which agreed to participate and 1 declined due to personal reasons. One patient was interviewed in the endocrinology outpatient clinic and 11 patients were interviewed on the neurosurgery ward. Data saturation was reached after 12 interviews which means that it is likely that no new information will arise during additional interviews (20).

Data collection

A semi structured interview guide was developed based on the attitudes, social influence and self-efficacy model (ASE-model) and expert knowledge (Table 1). This model was deliberately chosen as it helps to elaborate on demonstrated health behaviours and accompanying motives (21). Interviews were performed in Dutch.

Table 1: interview topics

1. How did patients experience the postoperative care on the neurosurgical ward?
– Nursing care
– Communication
– Complications
– Pre operative consultation in outpatient clinic
– Experience with IDUC
– Experience with fluid balance
2. How and to what extent was the patient involved in the decision to insert and remove the urinary catheter?
– Pre-operative information
– Shared decision making
– Role nurse/physician
– Influence bedrest
– Postoperative complications
3. How did patients experience the moment of IDUC insertion and removal?
– Comfort
– Physical situation
– Time of day
– Shared decision making
– Nurse's role
– Complications after removal
– Fluid balance before and after removal
4. What was the patient's role in monitoring the fluid balance?
– Bedpan/urinal
– IDUC
– Fluid balance chart
– Patient participation
– Collaboration with nurses
5. How did the IDUC affect mobilization and interaction with caregivers/family members?
– Stigma and feelings
– Barriers

Legend: IDUC = indwelling urinary catheters

Two pilot interviews were conducted. The topic list was adjusted twice based on the feedback of one test-participant and two participants who experienced difficulties explaining their role regarding IDUC removal. The audio-recorded interviews were held in a 3-month period, from mid-September until mid-November 2019, in a place and time that suited the participant. An oral summary was presented to each participant at the end of the interview to verify their story. Interviews were conducted by an experienced neurosurgical nurse who was not involved in the care of the participating patients.

Data analysis

The interviews were transcribed verbatim and analysed through thematic analysis (22). Two researchers independently conducted the coding process and discussed the findings with one another. Transcripts were read and reread to become familiar with the data. During the first phase of coding, the data was segmented into meaningful parts. These parts were provided with summarizing labels (codes). Subsequently, the codes were compared within and between transcripts by two researchers resulting in categories of codes on a more conceptual level. Finally, the created categories were described

into themes. An iterative approach was adopted to enable continuous evaluation of the data (23). The software program Atlas.ti 8.4.15 was used to structure the process of data analysis (24). Analysis was performed in Dutch and quotations were translated into English by a native speaker.

Ethical considerations

All study procedures were in accordance with the declaration of Helsinki and the medical ethics committee of Academic Hospital approved the study protocol (N19.015) (25). Participants received an information sheet and an informed consent form prior to the interviews. All participants provided written informed consent. Furthermore, participants were asked for their permission to record the interview with a voice recorder.

Patient and public involvement

The research question was developed by the researchers through their experience with the care for pituitary patients. Patients were not involved in the design and conduct of the study, the choice of outcome measures and recruitment for the study. Patients agreed with plans for dissemination of the results through scientific publication and education for nurses on the University hospital ward.

Results

Patient characteristics

The sample included 12 patients (Table 2) of which 83 percent (n = 10) were female. The mean age of the participants was 55 years (range: 39 – 73 years). Four patients had an IDUC inserted during the operation. Eight patients had an IDUC inserted postoperatively on the ward as they developed a retention bladder. One patient who received an IDUC during the operation developed a retention bladder after IDUC removal which required re-catheterization. The interviews had a duration of 23 – 58 minutes.

Table 2. Characteristics of study population (n = 12)

	n (%)
Gender	
Male	2 (17)
Female	10 (83)
IDUC inserted during surgery	4 (33)
IDUC inserted on ward	9 (75)
Retention bladder	9 (75)
Bedrest	7 (58)
Diabetes Insipidus	5 (42)
Cerebrospinal fluid leakage	1 (8)
	Mean (min – max)
Age	55 (39 – 73)
Length of hospital stay	4 (3 – 8)
Days IDUC inserted	2 (1 – 7)

Legend: IDUC = indwelling urinary catheters

Themes
Five major themes emerged: 1. conflicting information and pre-operative expectations, 2. IDUCs perceived as patient-friendly during bedrest, particularly for women, 3. little room for patients' opinions, 4. physical and emotional limitations and 5. fluid balance causes confusion. Quotations are included to illustrate the text.

Theme 1: Conflicting information and pre-operative expectations
During the pre-operative consult, five patients were informed that they would not receive an IDUC during the operation, whereas the information booklet stated the opposite. Three patients stated that they did not discuss the IDUC during the consult and did not read the booklet prior to surgery, so therefore they were unaware of the possibility of an IDUC. Three participants expressed feeling indifferent towards receiving an IDUC as they trusted the medical staff to make the appropriate decision.

All participants received information during the pre-operative consult on how to monitor the fluid balance after discharge; however, information on how to monitor the fluid balance during the hospital admission was provided to only four participants. Postoperatively, patients reported a large variation between nurses and their willingness to explain the fluid balance and having the patient monitor their input.

Two participants had undergone pituitary surgery in the past and were expecting to receive an IDUC based on their previous experiences. One participant was not content when she found out after her operation that she did not have an IDUC: *'I missed my IDUC. Because I had no discomfort from the IDUC the first time but I found it so dehumanizing to urinate on the bedpan, especially because I was unable to empty my bladder and needed an IDUC because of that. In the end, there were four towels under me and I was completely covered in urine'.*

The participants' pre-operative attitudes toward IDUCs leaned towards the negative and were predominantly influenced by stigmas and stories told by their friends and families. One participant explained: *'I was so scared of receiving and IDUC because I heard experiences from friends who had it (an IDUC) before and they said it hurts so badly to insert and remove it. So, after I heard all their terrible stories I thought no way I want an IDUC'.* Another patient added: *'It is what we were taught by our parents in the old days. People were very dramatic about IDUCs; for me it is still a very sensitive subject. I was shocked when I found out I probably was getting one but there are more people in the hospital with one, I know that. But I have this image in my head of an elderly person in a wheelchair and then carrying around that bag… it makes you look so ill'.*

Theme 2: IDUCs perceived as patient-friendly during bedrest, particularly for women
Eight female participants described their positive experiences with the IDUC in combination with postoperative bedrest. The general opinion was that providing a patient with an IDUC is more patient-friendly compared to having to use the bedpan. Ten out of the twelve participants felt that once the postoperative restriction mobility had ended, the IDUC had lost its added value.

Several complications associated with the bedpan were described. First, patients experienced a lack of privacy: *'In my room, one other patient was waiting for his operation, another person was waiting for his wife to come back from surgery. I'm sorry but I cannot urinate comfortably with others in the room. I couldn't urinate on the bedpan*

and I couldn't sit up straight in bed because I was on bedrest.' The placement of the IDUC was an issue because they needed around six or seven attempts. It took almost 40 minutes before the IDUC was placed. Very painful and embarrassing for me. But when the IDUC was finally placed it was such a relief". Second, using the bedpan was perceived as unsanitary: *'I had to urinate after the surgery but it was very difficult on the bedpan. I was so afraid that the urine would touch me or that I would wet my bed. It was so stressful and disgusting'.* Third, participants felt dependent on nurses' schedules resulting in patients developing a retention bladder or having to try to control their bladder. Finally, bedpans were associated with physical discomfort.

Participants explained that the IDUC was generally promptly removed by a nurse once the mobility restriction had ended, which was usually around noon. Postponed removal was caused by nurses being too busy or the nurse's wish that the physiotherapist mobilized the patient beforehand. Postponed removal, at 06:00 AM, made a strong impression on the patients: *'I was sleeping and it was very early in the morning and then she (the nurse) made a lot of noise, put all the lights on, pulled the IDUC out and that was it. While I was barely awake so I found that very uncomfortable'.*

Theme 3: Little room for patients' opinions
Patients had different perspectives on their role in the decision to insert or remove the IDUC. The four patients that had an IDUC inserted during surgery felt that they were adequately informed sufficiently during the outpatient clinic consult. If an IDUC was required postoperatively, patients felt that nurses did not inform them adequately about their options and did not take their opinion into consideration.

The eight patients who did not receive an IDUC during the operation felt pressured by nurses to urinate promptly after their return to the ward, which generated stress and anxiety: *'I just woke up after the surgery and then they [nurses] checked how much fluid there was in my bladder and they said that it was too much. I had 1.2 liters of urine in my bladder and then I had 5 minutes to urinate, but I was still groggy from the surgery. After time was up they inserted an IDUC. It all went so fast. I just wished they had inserted the IDUC during the surgery'* and *'I didn't really have an idea of what it would be like to have an IDUC. I never had one before and then all of a sudden they inserted one but they [nurses] didn't explain how they were going to do that, so that was very shocking to me. When I asked what was going to happen they explained a little bit but only after I asked for it. I just wish they told me earlier'.* These eight patients wished they were involved more in the shared decision making process.

Theme 4: physical and emotional limitations
The majority of the participants felt that an IDUC hinders mobilization and reduces the need to be active since it makes mobilization, especially to the bathroom, mostly redundant. One patient explained: *'All the hassle walking with the IDUC bag, I mean where do you put that thing. It limits my mobility so much. It really bothers me'.* The increased strain on the tube when walking or turning over in bed led to discomfort and caused two patients to be scared that the IDUC might be disconnected and leak urine. Being dependent on nurses was also mentioned as a barrier to mobilize: *'I barely left my bed because then the nurse needed to help me and attach the IDUC to something. I didn't want to bother them [nurses] too much because they were so busy all the time'.*

Reduced mobility was not experienced as bothersome by all participants: *'You feel it*

(the IDUC) pull and then you are afraid that it breaks so you have to be a bit careful, you cannot toss and turn in the bed. But lying still was no problem for me, I liked it'. A few participants felt uninformed by nurses and were left with questions about the post-operative mobilization policy. One participant illustrated: *'I was happy lying in the bed but if no one says that you can walk you will stay in bed just because you don't know if you are even allowed to walk with an IDUC'.*

Shame and fear of being judged for having an IDUC by nurses, other patients and visitors resulted in six participants to refrain from mobilizing to areas outside their room and by trying to cover the IDUC: *'I think it is embarrassing to walk around with an IDUC. That's why I tried to cover up the bag with a cardigan or large trousers. I know I should not worry about that but I found the IDUC so distasteful to see'.*

Since an IDUC is a foreign material, six patients who received an IDUC postoperatively experienced pain and discomfort when the IDUC was inserted. Patients complained of having bladder spasms, urine leaking next to the tube, and feeling the need to urinate after the IDUC was inserted: *'I woke up during the night and I had a feeling of urinating but that was impossible because I had an IDUC. I found that very annoying'.* After IDUC removal, three patients experienced a burning sensation when urinating which sometimes lasted for a couple of days.

Aside from physical discomfort, the interviews disclosed emotional strain caused by IDUCs. Four patients were afraid to develop a UTI as a result of the IDUC and these fears were confirmed by nurses. Before and shortly after the IDUC was removed, two patients were uncertain if their bladder could instantly regain its function and were worried that they could become incontinent. One participant explained: *'Just after the removal I was scared about what was going to happen. Did I have to run to the toilet every minute? At a certain point the IDUC gave me a feeling of peace because I didn't have to think about urinating. I was afraid that I needed to go to the bathroom 6 times each night and that I might be incontinent'.*

Theme 5: fluid balance causes confusion

During hospital admission, only two participants monitored their fluid intake. The personal fluid balance chart was used simultaneously by the patient, nurses and hospital food service workers which led to confusion and deviating charts. One participant illustrated: *'I lost complete control of my input because some nurses wrote it down but other nurses didn't so it was very confusing to me. I didn't know if I was supposed to monitor my intake or not'.* Participants also experienced difficulties with the fluid balance chart: *'I am always guessing how much ml is in one cup because the chart is difficult to understand. The nurses don't know either, they tell me different amounts per cup'.*

Four participants voiced concerns regarding monitoring the fluid balance at home: *'The nurse monitored what was going in and out so of course I am starting to worry now that I am going home and have to do it myself. The nurses already worry if there is half a liter difference in the fluid balance and I really don't understand what all the fuss is about'.* Ten patients would prefer more education on how to monitor the fluid balance as well as having the ability of guided practice.

Participants did not monitor the urinary output as they were not offered this option. Nine participants were willing to monitor their output during the hospital admission: *'I would like*

to monitor the output just so I know what is going on with my body. But I think it would be difficult to measure it on the day of the surgery since you are not feeling well then.. but from day two on it would have been no problem for me'. Only one participant explicitly stated that she would find it disgusting to monitor the output during the hospital stay.

Discussion

The aim of this study was to explore patient perspectives regarding IDUCs and monitoring the fluid balance after transsphenoidal pituitary and (para)sellar surgery. Despite patients describing a broad range of physical and emotional limitations related to IDUCs, they were preferred under the condition of bedrest, especially by females. Our findings suggest that patients' experiences are largely influenced by the information they receive from healthcare professionals both before and during their hospital admission. Additionally, our study shows that despite patients being instructed to monitor the fluid intake, nurses take on responsibility for this task leaving the patient unprepared to monitor the fluid balance after discharge.

Most female participants were in favor of IDUC use during the period of mandatory bedrest due to negative experiences with the bedpan. Loss of privacy, dependency on nurses, embarrassment, physical discomfort and hygiene aspects, all described in previous research, contributed to patients preferring IDUCs instead of bedpans (26).

This study confirms the importance of managing patients expectations and the consequences of patients receiving insufficient information (27). The quality of patient information is an important factor related to patient-centered care as it contributes to increased patient participation (28, 29). Patients experienced negative effects including stress and confusion by receiving conflicting and too little information. Although it was not mentioned in this study by any of the participants, literature additionally reported that patients may question the competence of the health care professionals due to contradictory and incomplete information (30).

Shared decision making was experienced as more present pre-operatively during scheduled consultations in contrast to acute situations, e.g. a retention bladder, postoperatively on the ward. Patients felt pressured and overlooked by nurses. Literature acknowledges this phenomenon and states that shared decision making is influenced by the physical setting and variability of the illness and that therefore acute situations may lead to a healthcare provider-led approach (31). This passive role assigned to patients postoperatively could be converted to an equal distribution of power between both parties through educational programs for nurses and strategies (e.g. decision flowcharts) that focus on increasing patients' decision-making capacity (32).

This study highlights the need for patient involvement in clinical care during the hospital admission to ensure a safe transition from the hospital to the home setting. The lack of training and guidance during the postoperative period could be explained by nurses feeling hesitant to relinquish responsibility to patients as patient safety could be jeopardized (33). Additionally, time constraints and the absence of a standardized educational protocol for nurses to train and educate patients could be of influence (34). A practice environment where patients and their relatives are trained to monitor both the fluid intake as well as the output to enable a gradual shift in responsibility, whilst still practicing in a safe and controlled setting, could strengthen patients' confidence (31, 35). To the best of our knowledge, no study has been conducted on such a specific educational programme.

Mobility challenges related to the IDUC, including prolonged time to ambulation (walking without the support of a nurse), immobility and discomfort, overlap with previous findings (36). In this study, patients reported feeling dependent on nurses' directives which could have delayed the moment of mobilization and thereby have a negative influence on the discharge date (37, 38).

We found that social influences, and stigmas could lead to embarrassment and fear of judgement from others. Although extensively described in long-term IDUC use, limited research has been conducted on the influence of social stigmas (e.g. embarrassment) in hospital settings (39, 40).

The incidence of urinary retention in this study was 75% (9 out of 12), which does not fall in the reported incidence range of 5 – 70, and is significantly higher than the reported 5% in general surgical populations (15, 41). This high incidence could partly be explained by postoperative bedrest; however, additional influencing factors including perioperative fluids, concurrent diseases, duration of the surgery and perioperative medications were not reported since they were outside the scope of this study (42). The results from this study could be different if the incidence of urinary retention, and subsequent catheterization rate, were lower.

A major strength of this study is that a combination of patients who received an IDUC during and after the operation were interviewed. Due to this approach, a broad range of experiences and perspectives was gathered. In addition, by applying a code-recode procedure during the data analysis, the validity of the study increased.

A limitation of the study was the relatively small and specific patient population, in addition to this study being conducted in a single ward in a University hospital. However, we do feel that the results can be used for different patient groups who also require fluid balances. Additionally, the results provide information that could be used by others to obtain insight into the patient perspective and complicated dilemmas patients face during hospital admission. Second, interviews were conducted both on the ward and in the outpatient clinic. It could be possible that perspectives from the patient who was interviewed several days after discharge changed due to having time to reflect on their hospital admission.

Further research is necessary to assess the possibilities of patient involvement in monitoring the fluid balance during hospital admission. Furthermore, a nurse-led training program should be developed and implemented on the ward to increase patient participation and build patients' confidence.

Conclusion

IDUC placement and fluid balance measurements are important aspects of peri-operative patient care after transsphenoidal pituitary gland and (para)sellar tumor surgery and have a major impact on the patient's overall evaluation. Patients who receive an IDUC during or after pituitary surgery experience a broad range of complications and are faced with a multitude of challenges related to communication and participation in care. In addition, insufficient information, predominantly provided by nurses, has a large impact on patient experiences and comprehension of the provided care. Patient involvement in both clinical care as well as shared decision making could be improved. Implementing an inpatient training program to increase patient participation in clinical care is likely to be beneficial for the transition from the hospital to the home setting.

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Chapter 4
The impact of early postoperative indwelling urinary catheter removal: a systematic review

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Abstract

Background
Indwelling urinary catheters (IDUCs) are associated with complications and early removal is therefore essential. Currently, it is unknown what the effect of a specific removal time is and what the consequences of this removal time are.

Research question
To present an overview of the available evidence to determine the effects of three postoperative IDUC removal times (after a certain number of hours, at a specific time of day and flexible removal time) on the development of complications in hospital.

Methods
PubMed, Medline, Embase, Emcare, and Cochrane Central Register of Controlled Trials were searched till June 6th 2021. Studies were included that described the effect of the removal time in relation to re-catheterization, urinary tract infections (UTIs), ambulation time, time of first voiding and hospital stay. The quality of the studies was assessed with the Newcastle-Ottawa Scale and the Cochrane Effective Practice and Organization of Care. A narrative descriptive analysis was performed. PRISMA guidelines were followed in reporting this review.

Results
Twenty studies were included from which 18 compared removal after a number of hours, 1 reported on a specific removal time and 1 reported on both topics. The results were contradicting regarding the hypothesis that later removal increases the incidence of UTIs. Earlier removal does not lead to a higher re-catheterization rate while immediate removal is beneficial for reducing the time to first ambulation and shortening the hospital stay. Studies reporting on specific removal times did not find differences in outcomes. No study addressed flexible removal time.

Conclusions
There is inconclusive evidence that earlier removal results in less UTIs, despite the incidence of UTIs increasing if the IDUC is removed ≥ 24 hours. Immediate- or after 1-2 day(s) removal does not lead to higher re-catheterization rates while immediate removal results in earlier ambulation and shorter length of hospital stay.

Implications of key findings
Nurses should focus on early IDUC removal while being aware of urinary retention.

Introduction

Indwelling urinary catheters (IDUCs) are frequently used in general hospital settings for various reasons. Literature indicates a variation in IDUC prevalence between populations and specialisms with a reported catheterization rate of approximately 12-77% (1). Indications for appropriate IDUC use include urologic surgeries, acute urinary retention, accurate measurement of urinary output in the critically ill, prolonged immobilization and comfortable end-of-life care (2). Perioperative placement during surgical procedures is common practice as they prevent bladder distention and incontinence in the anesthetized patient and facilitate the measurement of urine output during surgery (3).

Despite IDUCs being routinely placed during surgeries, they are associated with a broad range of infectious and non-infectious complications and impediments. Patients have a 3-7% risk of developing a catheter-associated urinary tract infection (UTI), per extra day the IDUC remains in place (4). The consequences of a UTI are extensive and range from higher morbidity, longer hospital stay, antibiotic use which can lead to antibiotic resistance, and extensive costs (5, 6). Other complications of the IDUC include structural injuries to the urinary tract, bleeding, the creation of a false passage, and patient discomfort (7). Additionally, IDUCs are known to have a negative influence on patients' mobility and participation in daily activities (8). After removing the IDUC, urinary retention has been reported as a commonly occurring complication which is associated with a risk of over distension and permanent detrusor muscle damage, which can occur from 7 to 48 hours after IDUC removal (9, 10). Controversy, the primary intervention for urinary retention is inserting an IDUC (11).

Although the catheter insertion, removal procedures, and management of the IDUC are traditionally the domain of the nursing staff, decisions regarding the removal of the IDUC often remain with the physician. However, there is no consensus among researchers regarding the responsibility of removing the IDUC (12, 13). Additionally, since there is no specific time defined for removing the IDUC postoperatively, as it depends on the policy of the hospital and the preference of the surgeon, this could lead to delayed removal (14). To reduce delayed removal and to empower the bedside nursing staff, literature advocates a nurse-driven protocol to remove the IDUC (15).

Several systematic reviews have been conducted on IDUC removal time concerning a specific type of surgery (16, 17) . However, to the best of our knowledge, no systematic review has been performed that compares complications after early versus delayed IDUC removal from a nursing perspective after a broad range of surgeries. It is unknown what the effect of a certain removal time is and what the consequences of this removal time are after non-specific surgeries. Therefore, this systematic review summarizes the evidence from randomized controlled trials, controlled trials, case-control- and cohort studies related to the effect of the removal time of a short-term indwelling urinary catheter on the development of complications in general surgery.

Aims

This systematic review aims to empower nurses and to reduce the risk of patient-related postoperative complications by presenting a systematic literature overview to determine the effect of the postoperative removal time of a short-term indwelling urinary catheter on the development of complications for surgical patients in the hospital. Complications include frequency of UTI occurrence, re-catheterization rate, ambulation time and moment of first voiding. Furthermore, the length of hospital stay in relation to IDUC removal was investigated.

Methods

Systematic review

A systematic review was used in this study to provide scientific knowledge from previous studies on the clinical impact of postoperative IDUC removal. Three postoperative removal times were investigated:

1. IDUC removal after a certain number of hours postoperatively (e.g. directly after surgery, 6 hours or 12 hours after surgery);
2. IDUC removal at a specific time of day (e.g. 06:00, 00:00, morning, evening, night);
3. Flexible removal time.

This systematic review was conducted according to the Cochrane Review Methodology and Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) (Supplementary File 1) (18, 19).

Data collection

Databases

A systematic literature search was performed in six databases: PubMed, Medline, Embase, Emcare, Web of Science, and Cochrane Central Register of Controlled Trials. The date of the most recent search of the register for this review is 6th of June 2021.

Search strategy and inclusion criteria

The search queries were formulated by three researchers using the patient/population, intervention, comparison and outcomes framework (PICO). We used the following research question: what is the effect of the postoperative removal time of a short-term indwelling urinary catheter on the development of complications for surgical patients in the hospital?. Search queries included index terms and keywords from the title and abstract. The following keywords were used to develop the search queries: 'urinary catheter', 'foley catheter', 'urethral catheter', 'catheter removal', 'removal of catheter', 'time', 'timing', 'early removal', 'late removal', 'flexible removal', 'morning removal', 'evening removal', 'midnight removal', 'surgerical procedures', 'postoperative period', 'perioperative nursing', 'complications', 'adverse effects', 'retention bladder', and 'recatheterization'. No limitations were applied on publication date and language. An expert health librarian at the University hospital guided the search. The full search strategy is included in Attachment 1.
Studies were eligible for inclusion if they: (a) included surgical patients aged ≥18 with an IDUC that is inserted perioperative; (b) reported on early versus late IDUC removal or a specific IDUC removal time or on the comparison between flexible duration versus fixed duration of the IDUC; (c) reported on complications post IDUC removal (occurrence of UTI, re-catheterization rate, ambulation time, moment of first voiding and length of hospital stay); (d) conducted in a hospital setting; (e) used a randomized, controlled trial design; controlled clinical trial design or a uncontrolled clinical trial design. Studies were excluded if: (a) they reported on patients with abnormalities of the genitourinary system; (b) they reported on patients undergoing urological surgery; (c) they reported on patients with epidural anesthesia or epidural pain medication (d) they reported on the use of antibiotics as a study intervention; (e) they were a systematic review; meta-analysis; individual case study; letter to the editor; conference abstract; or expert opinion; and (f) no full text was available. Requests for full text articles was sent to the authors of studies with no full text available. If they did not respond, a reminder was sent after 2 weeks.

Study selection

All studies identified from the search were systematically ordered using Endnote (version 20) and Microsoft Excel (version 2016). After removing the duplicates, two researchers independently reviewed title and abstract of the studies, followed by full texts review. Disagreements were discussed and, if necessary, a third researcher was consulted. After the initial search, the reference lists and citations of all included studies were examined to identify more relevant studies.

Data extraction

The data of the included studies was extracted in standard data extraction forms in Microsoft Excel (version 2016) by one researcher. A second researcher independently checked the extracted data. Differences were discussed between the researchers until consensus was reached. If consensus was not possible, a third researcher was consulted. The following data was collected from all included studies: first author, year of publication, country of origin, setting, study design, participant characteristics such as age and gender, type of surgery, postoperative IDUC removal time, primary and secondary outcomes. The primary outcome was the frequency of UTI occurrence. Secondary outcomes were re-catheterization rate, ambulation time, moment of first voiding and hospital stay.

Methodological quality

The methodological quality of the included articles was assessed independently by two researchers using tools to assess the risk of bias. The Newcastle-Ottawa Scale (NOS) was used for uncontrolled studies and the Cochrane Effective Practice and Organization of Care (EPOC) was used for randomized controlled trials and controlled before and after studies (20, 21). The NOS consists of three categories: (a) selection; (b) comparability; (c) and outcome. A number of stars can be awarded to each category, resulting in the conclusion: poor quality; fair quality; good quality (21). The EPOC tool consists of nine items that access risk of bias: (a) random sequence generation; (b) allocation concealment; (c) baseline outcome measurements similar; (d) baseline characteristics similar; (e) incomplete outcome data; (f) knowledge of the allocated interventions adequately prevented during the study; (g) protection against contamination; (h) selective outcome reporting; (i) and other risks of bias. Every item was scored with low, high, or unclear risk (20). Differences in judgement were discussed and, if necessary, resolved through intervention of a third reviewer.

Synthesis

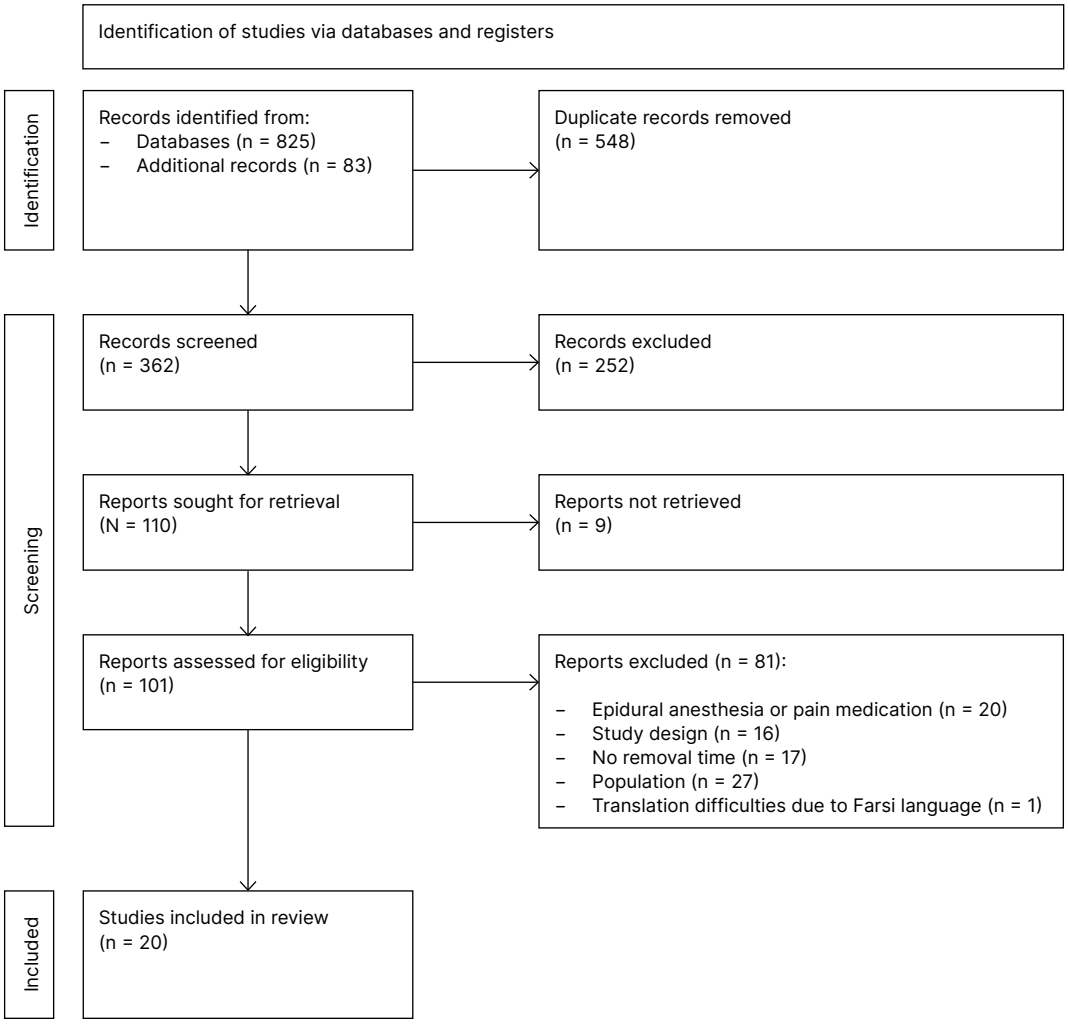
Given the heterogeneity of the target population (age, type of surgery), the variability in IDUC removal times and differences in methodological quality, performing a meta-analysis was infeasible. To summarize the overall evidence of the effectiveness of removal time of a short-term indwelling urinary catheter on the development of complications for surgical patients in hospital, a narrative descriptive synthesis was conducted. The extracted data was summarized in a baseline characteristics table and an evidence table. These tables are comprised of either descriptive statistics or, if available, the results (mean, median, percentages, hours) related to the primary and secondary objectives.

Results

Study selection

The search in the databases resulted in 825 results. The reference and citation search resulted in an additional 83 studies. After removing 546 duplicates, 362 articles remained. After screening on title and abstract, 110 articles were selected for full-text evaluation. Eight reports were not retrieved, resulting in 102 articles being assessed for eligibility. A total of 20 studies were included in this systematic review (figure 1), including 13 randomized controlled trials (22-34) and seven uncontrolled studies (35-41). Reasons for exclusion were: (a) the use of perioperative epidural anesthesia or pain medication (n= 20); (b) inappropriate study design, e.g. systematic review, letter to the editor, conference abstract and individual case study (n=16); (c) no specific removal time mentioned (n=17); (d) study population did not fit the inclusion criteria (n=27); and (e) not published in English or Dutch (n=2).

Figure 1: Prisma flow-chart



Methodological quality and risk of bias

The risk of bias in the controlled studies (n=13), scored with the EPOC tool (table 1), showed that eleven studies scored low risk on seven of the nine risk of bias criteria. For two studies (24, 26), there was an unclear risk of bias due to missing outcomes and high risks of bias that were likely to bias the results. The risk of bias of the uncontrolled studies (n=7), scored with the NOS, is shown in table 2. The quality of the majority of the included uncontrolled studies was poor, particularly due to a low score in the comparison domain due to a shortage of matching of exposed and unexposed individuals in the study design and/or a lack of correction for confounding in the analyses. One study did not perform statistical tests to measure the effectiveness of their de-implementation strategy (36). The quality of the studies was not of influence on the aggregation. For one study, there was an unclear and high risk for missing outcomes that were likely to bias the results (39).

Table 1. Risk of bias Cochrane Effective Practice and Organization of Care (EPOC) of controlled studies (*n*=13)

	Random sequence generation	Allocation concealment	Baseline outcome measurements similar	Baseline characteristics similar	Incomplete outcome data	Knowledge of the allocated interventions adequately prevented during the study	Protection against contamination	Selective outcome reporting	Other risks of bias	Score
Ahmed (2014)	+	+	+	+	?	?	+	+	+	7/9
Aref (2020)	+	+	+	+	?	?	+	+	+	7/9
Atilgan (2020)	+	+	+	+	?	?	+	+	−	6/9
Chai (2011)	+	+	−	+	+	+	+	+	+	8/9
Dunn (2003)	+	+	?	+	?	?	−	?	+	4/9
El-Mazny (2014)	+	+	+	+	+	?	+	+	+	8/9
Joshi (2014)	+	+	−	+	+	?	+	+	+	7/9
Liang (2009)	+	+	+	+	?	+	−	+	+	7/9
Onile (2008)	+	+	+	+	+	?	+	+	+	8/9
Ouladsahebmadarek (2012)	+	+	+	+	−	?	+	+	+	7/9
Sandberg (2019)	+	+	+	+	?	?	+	+	+	7/9
Sekhavat (2008)	+	?	+	+	?	+	+	+	+	7/9
Vallabh (2020)	+	+	+	+	?	?	+	+	+	7/9

Legend:
Green circle: Low risk of bias; yellow circle: Unclear risk of bias; Red circle: High risk of bias.
Low risk of bias: score 7 to 9. Unclear risk of bias: score 4 to 6; High risk of bias: score 0 to 3.

Table 2. Risk of Bias Newcastle-Ottawa Scale (NOS) of uncontrolled studies (*n*=7)

Author	Score selection	Score comparability	Score outcome	Conclusion
Campbell (2017)	☆☆☆	-	☆☆	Poor[1]
Dedden (2020)	☆☆☆	-	☆☆☆	Poor[1]
Duchalais (2019)	☆☆☆☆	☆	☆☆	Good[2]
Hung (2020)	☆☆☆☆	☆	☆☆	Good[2]
Karp (2018)	☆☆☆	-	☆☆	Poor[1]
Mengatto (2020)	☆☆☆☆	☆	☆☆	Good[2]
Yoo (2015)	☆☆☆	-	☆☆☆	Poor[1]

Legend:
[1]Poor quality: 0 or 1 star in selection domain OR 0 stars in comparability domain OR 0 stars or 1 stars in outcome domain.
[2]Good quality: 3 or 4 stars in selection domain AND 1 or 2 stars in comparability domain AND 2 or 3 stars in outcome domain

Study characteristics

Controlled studies

Thirteen of the 20 studies (65%) had a controlled design (table 3), including 11 randomized controlled trials (55%) (24-34) and two cluster RCTs (10%) (22, 23). Out of the 13 controlled studies, seven studies performed hysterectomies (22, 25, 28, 29, 32, 36, 39), three caesarean sections (23, 27, 30), one study a combination of hysterectomy and a laparotomy (31), one study colporrhaphy's (33), one study a sacrocolpopexy (34) and one study tension-free vaginal tape-procedures (24). Given the type of surgeries, the study population of all controlled studies were female.

In all controlled studies, IDUC removal was the intervention, however, the number of hours after which the IDUC was removed postoperatively differed between studies (table 4). We found nine different comparisons in these studies: (1) removing the IDUC immediately after surgery versus 24 hours postoperatively (25, 28, 30, 31, 33), (2) immediate versus after six hours versus after 24 hours removal (22, 23), (3) immediate versus after 18-24 hours removal (32), (4) after six hours versus 24 hours removal (24), (5) immediate versus after 12 hours removal (27), (6) six hours versus the morning after surgery removal (34), (7) immediate versus postoperative day one removal (26), (8) immediate versus after 24 hours versus after >48 hours removal versus discharged with IDUC (39) and (9) no IDUC inserted versus day one versus day two removal (29).
The study population in five studies had a mean age of < 40 years (23, 27, 30, 31, 33) and eight had a mean age > 40 year (22, 24-26, 28, 29, 32, 34).

Uncontrolled studies

Seven of the 20 studies (35%) had an uncontrolled design (table 3), including two cohort studies (10%) (35, 40), three retrospective reviews (20%) (37, 38, 41), one retrospective analysis (5%) (36) and one case-control study (5%) (39). Two of the seven studies performed hysterectomies (36, 39), one hysterectomies or bilateral pelvic node dissections (35), one rectal resections (37), one hysterectomies or trachelectomies (40), one proctectomies (38) and one performed mesorectal excisions (41). Three studies included males (37, 38, 41). Five uncontrolled studies focused their intervention on IDUC removal after a certain number of hours postoperatively (table 4). Comparisons were different in the included studies namely: a certain number of hours postoperatively and a specific removal time (35), immediate removal versus delayed removal (36), day one or two removal versus day three or later removal (38), four different removal times ranging from immediate removal to discharge with an IDUC (39), day one removal versus day seven removal (40). Campbell et al (2014) investigated both removal after a certain hours postoperatively (24 hours, 24-48 hours and 48-72 hours postoperatively) and removal at a specific moment (6 – 12 AM versus midnight). The intervention of the study from Duchalais (2019) focused IDUC removal between 6 and 8 AM. The mean age in the six studies was > 40. One study did not mentioned age (39). Not all studies reported on the operation time.

Table 3. Baseline characteristics of the studies

Author (year), Country	Study design	Type of Sugery	Gender (n)
Ahmed et al. (2014), Egypt	Cluster RCT	Uncomplicated abdominal hysterectomy	Female (221)
Aref (2020), Saudi Arabia	Cluster RCT	Cesarean section	Female (221)
Atilgan et al. (2020), Turkey	RCT	Tension-free vaginal tape	Female (70)
Campbell et al. (2017), Northern Ireland	Retrospective cohort study	Hysterectomy or bilateral pelvic node dissection	Female (78)
Chai et al. (2011), Hong Kong	RCT	Total abdominal hysterectomy	Female (70)
Dedden et al. (2020), Netherlands	Retrospective analysis	Laparoscopic hysterectomy	Female (242)
Duchalais et al. (2019), United States	Retrospective review	Rectal resection	Female (143) Male (274)
Dunn et al. (2003), United States	RCT	Cesarean dilvery or hysterectomy	Female (250)
El-Mazny et al. (2014), Egypt	RCT	Elective cesarean section	Female (300)
Hung et al. (2020), United States	Retrospective review	Proctectomy	Female (1117) Male (1312)
Joshi et al. (2014), India	RCT	Proctectomy	Female (70)
Karp et al. (2018), United States	Retrospective case study	Hysterectomy	Female (10 354)
Liang et al. (2009), Taiwan	RCT	Hysterectomy	Female (150)
Mengatto et al. (2020)	Cohort study	Hysterectomy or trachelectomy	Female (95)
Onile et al. (2008), Nigeria	RCT	Cesarean delivery	Female (200)
Ouladsahebmadarek et al. (2012), Iran	RCT	Hysterectomy and laparotomy	Female (200)
Sandberg et al. (2019), Netherlands	RCT	Hysterectomy	Female (155)
Sekhavat et al. (2008), Iran	RCT	Colporrhaphy	Female (90)
Vallabh et al. (2020), United States	RCT	Robotic-assisted laparoscopic sacrocolpopexy	Female (88)
Yoo et al. (2015), South Korea	Retrospective review	Total mesorectal excision or tumor-specific mesorectal excision	Male (102) Female (87)

Legend:
n = Sample size
RCT = Randomized controlled trial
SD = Standard Deviation
CI = Confidence Interval
[1]Unspecified value
[2]Median (Interquartile Range
a = immediate removal (0 h).
b = intermediate removal (6 h).
c = delayed removal (after 24 h).
d. 24–48 h after surgery.
e = 48–72 h after surgery.
f = delayed removal (unspecified).
g = removal postoperative Day 2.
h = delayed removal (12 h).
i = removal postoperative Day 1 or 2.
j = removal postoperative Day 3 or later.
k = delayed removal (>48 h).
l = discharged home with IDUC.
m = no IDUC placed during surgery.
n = removal postoperative Day 2.
o = removal postoperative Day 7.
p = delayed removal (18–24 h).
q = morning after surgery.

Intervention	Age in years, mean (SD or 95% CI)	Operation time in minutes, mean (SD or 95% CI)
a. Immediate removal (0 h) b. Intermediate removal (after 6 h) c. Delayed removal (after 24 h)	a. 59.1 (8.3) b. 58.3 (6.9) c. 61.3 (0.5)	a. 95.6 (10.9) b. 96.4 (13.1) c. 98.9 (11.5)
a. Immediate removal (0 h) b. Intermediate removal (after 6 h) c. Delayed removal (after 24 h)	a. 26.1 (4) b. 25.3 (2) c. 25.6 (3)	a. 45.36 (15.3) b. 43.91 (13.9) c. 48.48 (12.4)
b. Intermediate removal (after 6 h) c. Delayed removal (after 24 h)	b. 42.8 (6.8) c. 44.6 (4.34)	b. 35.25 (21.8) c. 36.18 (23.1)
c. Delayed removal (after 24 h) d. 24-48 h after surgery e. 48-72 h after surgery	40.7 (8.74)	-
a. Immediate removal (0 h) c. Delayed removal (after 24 h)	a. 46.4 (3.9) c. 46.4 (4.0)	a. 84.3 (2.1) c. 85.6 (0.8)
a. Immediate removal (0 h) f. Delayed removal	50 (12)	128 [108;164]
Removal of unirary catheter, post operative day 1 between 6 and 8 in the morning	59 [50;68]	229 [171;301]
a. Immediate removal (0 h) g. Removal postoperative day 1	47 [25;72]	-
a. Immediate removal (0 h) h. Delayed removal (after 12 h)	a. 24.5 (4.2) h. 23.8 (3.9)	-
i. Removal postoperative day 1 or 2 j. Removal postoperative day 3 or later	i. 52 (16.3) j. 53.5 (16.4)	i. 220 [164;291] j. 239 [178;304]
a. Immediate removal (0 h) c. Delayed removal (after 24 h)	a. 46.80 (6.9) c. 45.09 (6.44)	a. 97.86 (21.39) c. 107.29 (15.30)
a. Immediate removal (0 h) c. Delayed removal (after 24 h) k. Delayed removal (after >48h) l. Discared home with indweling catheter	-	-
m. No IDUC g. Removal postoperative day 1 n. Removal postoperative day 2	m. 43.7 (3.9) g. 45.7 (3.5) n. 45.7 (5.8)	m. 142.5 (102.2) g. 143.9 (81.5) n. 154.2 (81.6)
g. Removal postoperative day 1 o. Removal postoperative day 7	g. 40 o. 44	-
a. Immediate removal (0 h) c. Delayed removal (after 24 h)	a. 31.67 (6.042) c. 32.72 (5.96)	-
a. Immediate removal (0 h) c. Delayed removal (after 24 h)	a. 37.48 (8.85) c. 39.48 (9.54)	a. 100.2 (21) c. 105.6 (22.8)
a. Immediate removal (0 h) p. Delayed removal (after 18-24 h)	a. 49.3 (10.5) p. 51.5 (11.9)	a. 116.0 (44.0) p. 105.4 (29.6)
a. Immediate removal (0 h) c. Delayed removal (after 24 h)	a. 38.9 (2.9) c. 39 (3.8)	a. <30 min: 18 (40%) 30-45 min: 22 (48.9%) >45 min: 5 (11%) c. <30 min: 20 (44.4%) 30-45 min: 21 (46.7%) >45 min: 4 (8.9%)
b. Intermediate removal (after 6 h) q. Mornging after sugery	b. 59.52 (8.5) q. 59.57 (11.2)	b. 202.5 [120;284] q. 192.5 [127;391]
g. Removal postoperative day 1 n. Removal postoperative day 2	a. 64.5 [36;82] n. 66.0 [27;87]	-

Table 4. Removal time indwelling catheter

Author (year)/ removal time	No IDUC	Hours						
		0	6	12	18-24	< 24	24	> 24
Ahmed (2014)		+	+				+	
Aref (2020)		+	+				+	
Atilgan (2020)			+				+	
Campbell (2017)						+		
Chai (2011)		+					+	
Dedden (2020)		+						
Dunn (2003)		+						
El-Mazny (2014)		+		+				
Hung (2020)								
Joshi (2014)		+						
Karp (2018)		+					+	
Liang (2009)	+							
Mengatto (2020)								
Onile (2008)		+					+	
Ouladsahebmadarek (2012)		+					+	
Sandberg (2019)		+			+			
Sekhavat (2008)		+						+
Vallabh-Patel (2020)			+					
Yoo (2015)								

Author (year)/removal time	6:00 AM	Between 6 – 8 AM
Campbell (2017)		
Duchalais (2019)		×

	Days									Other	
	1	Morning after surgery	Day after surgery	1 or 2	2	> 48	Between 1-3	> 3	7	Delayed	Discharged home
							+				
										+	
	+										
				+				+			
	+										
						+					+
	+				+						
	+								+		
		+									
			+		+						
	Morning (between 6 AM – 12 AM)				22:00 PM				Midnight (00:00)		
			×						×		

Table 5. Removal time and complications of an IDUC

Author (year)	n total	Removal time (n)	Urinary tract infections (%)	P value	Recatheter-isation (%)
Ahmed (2014)	221	a. 0h after surgery (73) b. 6h after surgery (81) c. 24h after surgery (67)	a. 1 (1.4) b. 3 (3.7) c. 10 (14.9)	0.008 c. versus a. & b.	a. 12 (16.4) b. 2 (2.5) c. 0 (0)
Aref (2020)	221	a. 0h after surgery (73) b. 6h after surgery (81) c. 24h after surgery (67)	a. 1 (1.4) b. 3 (3.7) c. 9 (13.4)	0.005 Difference among groups and c versus a. & b.	a. 12 (16.4) b. 2 (2.5) c. 0 (0)
Atilgan (2020)	70	b. 6h after surgery (35) c. 24h after surgery (35)	b. 4 (11.4) c. 12 (34.2)	0.042	b. 4 (11.4) c. 0 (0)
Campbell (2017)	78	c. 24h after surgery (14) d. 24-48h after surgery (47) e. 48-72h after surgery (17)	-	-	34 (44%)
Chai (2011)	70	a. 0h after surgery (35) c. 24h after surgery (35)	a. 4 (11.4) c. 10 (28.6)	0.133	a. 4 (11.4) c. 0 (0)
Dedden (2020)	242	a. 0h after surgery (194) f. Delayed removal after surgery (48)	a. 18 (9.3) f. 10 (20.8)	-	a. 9 (4.6) f. 1 (2.1)
Dunn (2003)	250	a. 0h after surgery (125) g. Postopertive day 1 (125)	a. 3 (2.4) b. 3 (2.4)	NS	a. 6 (2.4) b. 3 (2.4)
El-Mazny (2014)	300	a. 0h after surgery (150) h. 12h after surgery (150)	a. 14 (9.3) h. 29 (19.3)	0.02	a. 4 (2.7) h. 1 (0.7)
Hung (2020)	2,429	i.Postopertive day 1 or 2 (1,176) j. Postopertive day 3 or later (1,253)	i. 35 (2.98) j. 42 (3.35)	0.680	i. 150 (12.8) j. 130 (10.4)
Joshi (2014)	70	a. 0h after surgery (35) c. 24h after surgery (35)	a. 3 (8.5) c. 9 (22.8)	0.222	a. 3 (8.5) c. 0 (0)
Karp (2018)	10,354	a. 0h after surgery (2,915) c. 24h after surgery (6,297) k. >48h after surgery (802) l. Discared home with indweling catheter (340)	a. 37 (1.3) c. 130 (2.1) k. 33 (4.1) l. 22 (6.5)	< 0.0001	-
Liang (2009)	150	m. No IDUC (50) g. Postoperative day 1 (50) n. Postoperative day 2 (50)	m. 2 (4) g. 3 (6) n. 9 (18)	0.034	m. 17 (34) g. 6 (12) n. 5 (10)
Mengatto (2020)	95	g. Postoperative day 1 (48) o. Postoperative day 7 (47)	g. 2 (4.2) o. 8 (14.9)	0.09	g. 14 (29.2) o. 16 (34)
Onile (2008)	200	a. 0h after surgery (86) c. 24h after surgery (89)	a. 7 (8.1) c. 10 (11.2)	0.489	a. 1.2 (1) c. 0 (0)
Ouladsa-heb-madarek (2012)	200	a. 0h after surgery (100) c. 24h after surgery (100)	a. 3 (3) c. 9 (9)	0.074	a. 3 (3) c. 0 (0)
Sandberg (2019)	155	a. 0h after surgery (74) p. 18-24h after surgery (81)	a. 3 (4.1) p. 8 (9.9)	0.215	a. 10 (13.5) p. 0 (0)
Sekhavat (2008)	90	a. 0h after surgery (45) c. 24h after surgery (45)	a. 2 (4.5) c. 9 (15)	0.001	a. 3 (6.6) c. 11 (24.5)
Vallabh (2020)	88	b. 6h after surgery (44) q. Morning after surgery (44)	b. 4 (9) q. 0 (0)	0.041	b. 16 (36) q. 2 (4.5)
Yoo (2015)	189	g. Postoperative day 1 (104) n. Postoperative day 2 (85)	-	-	g. 5 (4.8) n. 4 (4.7)

Legend:
n = sample size.
RCT = randomised controlled trial.
SD = standard deviation.
CI = confidence interval.
NS = not significant.
a = 0 h after surgery.
b = 6 h after surgery.
c = 24 h after surgery.
d. 24–48 h after surgery.
e = 48–72 h after surgery.
f = delayed removal (unspecified).
g = removal postoperative Day 2.
h = delayed removal (12 h).
i = removal postoperative Day 1 or 2.
j = removal postoperative Day 3 or later.
k = delayed removal (>48 h).
l = discharged home with IDUC.
m = no IDUC placed during surgery.
n = removal postoperative Day 2.
o = removal postoperative Day 7.
p = delayed removal (18–24 h).
q = morning after surgery.

	P value	**Time of ambulation in hours (SD or 95% CI)**	**P value**	**First voiding in hours (SD)**	**P value**	**Hospital stay in days (SD or 95% CI)**	**P value**
	0.001 a. versus b. & c.	a. 4.1 (1.8) b. 6.8 (1.7) c. 10.3 (2.5)	0.001 b. & c. versus a.	-	-	a. 3.2 (1.6) b. 3.4 (1.5) c. 5.6 (1.2)	0.001
	0.001 Difference among three groups and a versus b. & c.	a. 4.1 (1.8) b. 6.8 (1.7) c. 10.3 (2.5)	0.001 Difference among groups.	-	-	a. 1.9 (1.4) b. 2.4 (1.3) c. 3.9 (1.1)	0.01
		0.069	-	-	-	-	b. 0.5 (0.14) c. 1.2 (0.21)
	-	-		-	-	4.2 (1.3)	-
	0.114	-	-	-	-	a. 3.3 (0.6) c. 3.8 (2.1)	-
	-	-	-	-	-	-	-
	NS	-	-	-	-	-	-
	0.371	a. 4.8 (1.1)	h. 9.5 (1.2)	<0.001	a. 4.8 (1.1)	h. 13.4 (1.3)	<0.001
	0.076	-	-	-	-	i. 5.26 [4.0;8.0] j. 7 [4.52;10.0]	<0.001
	0.077	-	-	-	-	-	-
	-	-	-	-	-	-	-
	0.003	-	-	-	-	-	-
	0.66	-	-	-	-	-	-
	0.986	a. 7.82 (1.85) c. 8.72 (2.48)	0.842	-	-	a. 6.8 (1.76) c. 6.9 (1.82)	0.879
	1	a. 15.53 (6.45) c. 24.36 (4.66)	<0.0001	-	-	a. 2.2 (0.68) c. 2.7 (0.75)	<0.0001
	0.88	a. 5.7 [0.8;23.3] p. 21.0 [1.4;29.9]	<0.001	-	-	a. 1.5 [0;4] p. 1 [1;4]	0.954
	0.008	a. 5.9 (1.7) c. 17.1 (2.4)	0.01	-	-	a. 1.0 (0.13) c. 2.2 (0.20)	0.003
	<0.001	-	-	-	-	-	-
	1	-	-	-	-	-	-

Effects of interventions

IDUC removal after a certain number of hours postoperatively (e.g. directly after surgery, 6 hours after surgery, 12 hours after surgery

Nineteen studies compared IDUC removal at different times postoperatively in relation to at least one of the following complications: frequency of UTI occurrence, re-catheterization rate, ambulation time, moment of first voiding and hospital stay (table 5).

Urinary tract infection

Seventeen studies evaluated the development of UTIs after various postoperative IDUC removal times. Seven of these seventeen studies (41%) found a positive and significant effect between late IDUC removal and the development of UTIs (22-24, 27, 29, 33, 34, 39). Three studies found a statistically significant effect between the latest (two days or 24 hours postoperatively) and the fastest IDUC removal time (immediate removal, after six hours or after one day) when comparing three different time points postoperatively. Two days or 24 hours after surgery compared to not inserting the IDUC or removing the catheter immediately after surgery or after six hours or after one day, with 14.9%, 13.4% and 18% UTIs in the latest removal groups compared to 1.4% and 4% in the earliest removal groups, respectively. (22, 23, 29).

Four studies found a statistically significant effect between later IDUC removal (12 hours after surgery/24 hours after surgery/>48 hours after surgery/discharged with IDUC/ morning after surgery removal) and UTIs, with 34.2%, 19.3%, 6.5% and 15% UTIs in the latest removal groups compared to 11.4%, 9.3%, 1.3% and 4.5% in the earliest removal groups, respectively (24, 27, 33, 39). One study (6%) found a statistically significant effect between IDUC removal after six hours and removal the morning after surgery, with 9% and 0% UTIs, respectively (34).

Eight studies (47%) did not report a significant effect between later removal time and UTIs (25, 26, 28, 30-32, 38, 40). One study (6%) did not report a P-value (36).

Re-catheterization

Eighteen studies evaluated the re-catheterization rate after the various postoperative IDUC removal times. In total, five studies (28%) reported a significant result between re-catheterization and earlier IDUC removal (22, 23, 29, 33, 34). These studies reported a re-catheterization rate of 16.4 – 36% in their earliest removal group compared to 0 – 6.6% in their latest removal group. Eleven studies did not display a significant relation between re-catheterization and earlier removal time (24-28, 30-32, 38, 40, 41). Two studies did not report a P-value: Campbell et al (2017) found a re-catheterization rate of 44%, however, this percentage is in relation to the whole study population. Dedden et al (2020) reported a re-catheterization rate of 4.6% in their early removal group compared to 2.1% in their late removal group.

Ambulation time

Seven studies reported on ambulation time. Six of those studies (86%) found a statistically significant relation between earlier IDUC removal and shorter time until first ambulation (22, 23, 27, 31-33). In these studies, the earliest IDUC removal group walked without the aid of assistant devices and/or nurses 1.6 – 3.6 times earlier (in hours) than the latest removal group. Onile et al (2008) did not report a significant effect.

First voiding

One study reported on the relation between IDUC removal and first void and found that

the group with immediate removal early voided after an average of 4.8 hours compared to 13.4 hours in the 12 hours postoperative removal group, which resulted in a statistically significant effect (27).

Hospital stay
Eleven of the nineteen included studies reported on the length of hospital stay in relation to IDUC removal. Seven of these studies (58%) reported a statistically significant effect between earlier IDUC removal and shorter length of hospital stay (22-24, 27, 31, 33, 38). In these studies, the earliest IDUC removal group stayed in the hospital 0.5 – 2.4 days shorter than the latest removal group. No significant effect is reported by two other studies (30, 32). One study did not report a P-value (25).

IDUC removal at a specific time of day (e.g. 06:00, 00:00, morning, evening, night)
Two studies investigated IDUC removal at a specific time of day (between 06:00 – 12:00 AM, midnight and between 06:00 – 08:00 AM) (table 4) in relation to UTIs, re-catheterisation and voiding dysfunction (35, 37). In the study from Duchalais et al (2019), 11 (6%) of the 172 patients (41%) who required in-and-out catheterization due to voiding problems after IDUC removal, developed a UTI (p = 0,002). In the group who did not need in-and-out catheterization (245 patients), 2 patients (1%) developed a UTI. The IDUC was re-inserted in 14 patients. The length of the hospital stay was longer in the in-and-out catheterization group with a mean of 4 days compared to 5 days in the non in-and-out catheterization group (p < 0.001).

Campbell et al (2017) described that 51 of the 78 participants had the IDUC removed in the morning between 06:00 – 12:00 AM and 23 patients had IDUC removal at midnight. Voiding dysfunction was registered in 21 patients (41%) of the morning group versus 11 (48%) of the midnight group (p = 0.59).

Flexible removal.
No studies were found that investigated flexible removal times.

Discussion

Our study sought to assess the effects of three postoperative removal times (after a certain number of hours postoperatively, at a specific time of day and flexible removal time) of an IDUC on the development of complications for surgical patients in hospitals. Prevention and early recognition of postoperative complications are a major part of the nursing profession which benefit both the medical team as well as the patient.

Of the included twenty included studies, nineteen studies investigated IDUC removal after a certain number of hours postoperative in relation to five complications. However, due to not all studies providing a precise definition of the amount of hours passed before IDUC removal (e.g. stating day 1 or day 2 after surgery), interpretation and comparison of the results was challenging. Consequently, the results from this review were inconclusive regarding the hypothesis that later IDUC removal increases the incidence of UTIs. This finding is in contrast with previous research, which assumes that patients have a 3-7% risk of developing a catheter-associated urinary tract infection, per extra day the IDUC remains in place (4). One explanation for these results could be the short duration of IDUC placement in the included studies. However, extending the duration of postoperative catheterization for ≥ 24 hours postoperatively did increase the incidence of UTIs compared to early removal times.

Urinary retention, defined as the inability to void in the presence of a full bladder, frequently occurs after anesthesia, surgery and IDUC removal which requires bladder catheterization (9). Since literature indicates that the risk of urinary retention, and subsequent catheterization, increases when epidural or spinal anesthesia is used during surgery, we decided to include only studies that used general anesthetics (42, 43). Additionally, we excluded urological surgeries as IDUCs can be used as an intervention that is beneficial for the healing process during the postoperative period (2). Thus, in this review, we mostly included studies who performed gynecological surgeries, which automatically results in a higher population females, thereby complicating direct generalization to other surgical specialisms such as vascular surgery, neurosurgery and thoracic surgery. Regarding urinary retention, most studies in this review show that earlier IDUC removal, immediate removal or on day one or two, does not lead to a significantly higher re-catheterization rate compared to later IDUC removal. This finding is of relevant for daily practice since nurses could have a tendency to leave the IDUC in place due to a fear of re-catheterization (44).

The findings of this systematic review show that early IDUC removal leads to a shorter time until first ambulation and a shorter length of hospital stay, especially when the IDUC was removed immediately after surgery. Saint et al. underlined that IDUCs are known to negatively affect patient mobility and participation in daily activities (8). Moreover, by reducing the time to ambulation a broad range of complications including thrombosis and embolisms could be prevented (45). Early ambulation is stated to be of great importance after surgical interventions due to the positive effect on patient recovery, that results in a reduced length of hospital stay and which in turn as has as substantial societal impact by limiting costs (46, 47). For patients, early IDUC removal is of great clinical significance as it reduces discomfort and feelings of shame that patients might experience (48). Patients can feel ashamed when others notice the IDUC as this can make them feel less competent. Additionally, the IDUC makes patients feel dependent on nurses in simple daily tasks (49).

This systematic review included only one study that reported on first voiding after IDUC removal, which revealed that the 0-hour group voided significate earlier than the later removal group. While prior studies agree that difficulties regaining normal bladder function frequently occur after catheter removal, there is little known about the relation between earlier IDUC removal and urinary dysfunction. Bladder training to decrease bladder dysfunction is an intervention widely studied, however, there is no consensus whether the use of intermittent clamping before removal reduces urinary retention (50, 51).
In this systematic review we included two studies who investigated IDUC removal at a specific time of day between 6 and 12 AM and at noon. However, only one study compared two specific removal times which showed no difference in voiding dysfunction between the morning and midnight group. Since this review found little evidence regarding the best IDUC removal time, future trials are required to investigate the effects of a specific removal time. Regarding flexible removing times, this review does not provide any information as there are no trials known with this research question.

In order to appreciate the finding of this systematic review, some limitations need to be considered. First, the interpretation of the results described in this systematic review is complicated due to differences in the included studies (e.g. types of surgery, removal times, and mostly female population). Due to the heterogeneity of the studies, it was not possible to conduct a meta-analysis. Second, since no studies specifically addressed

the comparison between flexible duration versus fixed duration of the catheter, this could not be reviewed. Third, selection bias might have occurred as a consequence of excluding one article written in a foreign language. In this review, we had to exclude one study written in Farsi language due to translation difficulties. Fourth, only two articles included males in their study population. This could have influenced the results since females have a higher risk of UTIs (52). Finally, due to the exclusion criteria multiple studies with respect to urological surgeries were excluded. Therefore, this review is not representable for patients with urological conditions. A strength of this study is that the search was systematically conducted by multiple researchers and the help of a health librarian expert which ensured a critical assessment of the data. The review has been peer-reviewed by multiple researchers.

Before new removal strategies and interventions can be developed, we suggest to perform studies to acquire more insight into the consequences of flexible removing times. In addition, there is a need for studies that focus on a broader range of surgical indications with an equal distribution of sexes between the participants. Additionally, studies should evaluate the use of nurse-driven protocols that empower the nursing profession in IDUC management.

Conclusion

This systematic review presents a literature overview to determine the effectiveness of the postoperative removal time of an IDUC on the development of complications for surgical patients in the hospital. It became clear that there is inconclusive evidence that earlier postoperative removal results in less UTIs. However, the incidence of UTIs does increase if the IDUC is removed ≥ 24 hours postoperatively. Additionally, immediate- or after 1-2 day(s) removal does not lead to higher re-catheterization rates while immediate removal results in a shorter time until first ambulation and length of hospital stay. Therefore, based on the available evidence, removing the IDUC immediately after surgery while ensuring close monitoring of urinary retention is recommended to reduce UTIs and encourage postoperative recovery.

Relevance to clinical practice

This review does not provide a definite answer as to what IDUC removal time is most beneficial in relation to postoperative complications in surgical patients. However, the presented overview gives insight in the possible removal times of the IDUC in gynecological surgeries. As evidence indicates that removal time does not have a significant relation to UTIs and the rate of re-catheterization, nurses should focus on early IDUC removal to increase patient comfort while being aware of the risk of urinary retention and urinary tract infections.

What does this paper contribute to the wider global clinical community

The systematic review presents available evidence on early indwelling urinary catheter removal with a translation to clinical nursing practice.
As removal time does not have a clear and distinct relation to UTIs and re-catheterization rate, nurses should focus on early removal to reduce patient discomfort.

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Appendix: Search strategy

Database	Search Strategy	Number of references	Number of unique references
a. PubMed (Totaal d.d. 23-7-2021)	**(**((”Urinary Catheters”[majr] OR ”Urinary Catheters”[ti] OR ”Urinary Catheter”[ti] OR ”Ureteral Catheter”[ti] OR ”Ureteral Catheters”[ti] OR ”Urethral Catheter”[ti] OR ”Urethral Catheters”[ti] OR ”urinary tract catheter”[ti] OR ”urinary tract catheters”[ti] OR ”foley catheter”[ti] OR ”foley catheters”[ti] OR ”folley catheter”[ti] OR (”urinary”[ti] AND (”catheter”[ti] OR ”catheters”[ti])))) AND (”Device Removal”[Mesh] OR ”catheter removal”[tw] OR ”removal of catheter”[tw] OR ”removing catheters”[tw] OR ”removal”[tw] OR ”remov*”[tw] OR ”removal practice”[tw] OR ”removal practices”[tw]) AND (”Time”[Mesh] OR ”Time Factors”[mesh] OR ”timing”[tw] OR ”time”[tw] OR ”evening”[tw] OR ”morning”[tw] OR ”midnight”[tw] OR ”night”[tw] OR ”early removal”[tw] OR ”earlier removal”[tw] OR ”early catheter removal”[tw] OR ”earlier catheter removal”[tw] OR ”early urinary catheter removal”[tw] OR ”earlier urinary catheter removal”[tw] OR ”late removal”[tw] OR ”late catheter removal”[tw] OR ”late urinary catheter removal”[tw] OR ”early foley catheter removal”[tw] OR ”late foley catheter removal”[tw] OR ”After-Hours Care”[Mesh] OR ”Night Care”[Mesh] OR ”Day Care, Medical”[Mesh]) AND (”Surgical Procedures, Operative”[Mesh] OR ”surgery”[Subheading] OR ”Surgical*”[tw] OR ”surgery”[tw] OR ”Postoperative Period”[Mesh] OR ”Postoperative Care”[Mesh] OR ”Perioperative Period”[Mesh] OR ”Perioperative Care”[Mesh] OR ”Perioperative Nursing”[Mesh] OR ”Intraoperative Period”[Mesh] OR ”Intraoperative Care”[Mesh] OR ”acute care”[tw]) AND (”complications”[Subheading] OR ”complications”[tw] OR ”complication”[tw] OR ”Postoperative Complications”[Mesh] OR ”Intraoperative Complications”[Mesh] OR ”Urinary Catheters/adverse effects”[mesh] OR ”postdischarge problems”[tw] OR ”post discharge problems”[tw] OR ”postdischarge adverse”[tw] OR ”post discharge adverse”[tw] OR ”adverse effects”[subheading] OR ”retention bladder”[tw] OR ”Urinary Retention”[Mesh] OR ”urinary retention”[tw] OR ”recatheterisation”[tw] OR ”recatheterization”[tw] OR ”recatheter*”[tw]) NOT (”Animals”[mesh] NOT ”Humans”[mesh])) **OR** ((”Urinary Catheters”[Mesh] OR ”Urinary Catheters”[tw] OR ”Urinary Catheter”[tw] OR ”Ureteral Catheter”[tw] OR ”Ureteral Catheters”[tw] OR ”Urethral Catheter”[tw] OR ”Urethral Catheters”[tw] OR ”urinary tract catheter”[tw] OR ”urinary tract catheters”[tw] OR ”foley catheter”[tw] OR ”foley catheters”[tw] OR ”folley catheter”[tw] OR (”urinary”[tw] AND (”catheter”[tw] OR ”catheters”[tw])))) AND (”Device Removal”[majr] OR ”catheter removal”[ti] OR ”removal of catheter”[ti] OR ”removing catheters”[ti] OR ”removal”[ti] OR ”remov*”[ti] OR ”removal practice”[ti] OR ”removal practices”[ti]) AND (”Time”[Mesh] OR ”Time Factors”[mesh] OR ”timing”[tw] OR ”time”[tw] OR ”evening”[tw] OR ”morning”[tw] OR ”midnight”[tw] OR ”night”[tw] OR ”early removal”[tw] OR ”earlier removal”[tw] OR ”early catheter removal”[tw] OR ”earlier catheter removal”[tw] OR ”early urinary catheter removal”[tw] OR ”earlier urinary catheter removal”[tw] OR ”late removal”[tw] OR ”late catheter removal”[tw] OR ”late urinary catheter removal”[tw] OR ”early foley catheter removal”[tw] OR ”late foley catheter removal”[tw] OR ”After-Hours Care”[Mesh] OR ”Night Care”[Mesh] OR ”Day Care, Medical”[Mesh]) AND (”Surgical Procedures, Operative”[Mesh] OR ”surgery”[Subheading] OR ”Surgical*”[tw] OR ”surgery”[tw] OR ”Postoperative Period”[Mesh] OR ”Postoperative Care”[Mesh] OR ”Perioperative Period”[Mesh] OR ”Perioperative Care”[Mesh] OR ”Perioperative Nursing”[Mesh] OR ”Intraoperative Period”[Mesh] OR ”Intraoperative Care”[Mesh] OR ”acute care”[tw]) AND (”complications”[Subheading] OR ”complications”[tw] OR ”complication”[tw] OR ”Postoperative Complications”[Mesh] OR ”Intraoperative Complications”[Mesh] OR ”Urinary Catheters/adverse effects”[mesh] OR ”postdischarge problems”[tw] OR ”post discharge problems”[tw] OR ”postdischarge adverse”[tw] OR ”post discharge adverse”[tw] OR ”adverse effects”[subheading] OR ”retention bladder”[tw] OR ”Urinary Retention”[Mesh] OR ”urinary retention”[tw] OR ”recatheterisation”[tw] OR ”recatheterization”[tw] OR ”recatheter*”[tw]) NOT (”Animals”[mesh] NOT ”Humans”[mesh]))**)**	228	228

b. MEDLINE via OVID (Totaal d.d. 5-3-2021)	**(**((exp *"Urinary Catheters"/ OR "Urinary Catheters".ti OR "Urinary Catheter".ti OR "Ureteral Catheter".ti OR "Ureteral Catheters".ti OR "Urethral Catheter".ti OR "Urethral Catheters".ti OR "urinary tract catheter".ti OR "urinary tract catheters".ti OR "foley catheter".ti OR "foley catheters".ti OR "folley catheter".ti OR ("urinary".ti AND ("catheter".ti OR "catheters".ti))) AND (exp "Device Removal"/ OR "catheter removal".mp OR "removal of catheter".mp OR "removing catheters".mp OR "removal".mp OR "remov*". mp OR "removal practice".mp OR "removal practices".mp) AND (exp "Time"/ OR exp "Time Factors"/ OR "timing".mp OR "time".mp OR "evening".mp OR "morning".mp OR "midnight".mp OR "night".mp OR "early removal".mp OR "earlier removal".mp OR "early catheter removal".mp OR "earlier catheter removal".mp OR "early urinary catheter removal".mp OR "earlier urinary catheter removal".mp OR "late removal".mp OR "late catheter removal".mp OR "late urinary catheter removal".mp OR "early foley catheter removal".mp OR "late foley catheter removal".mp OR exp "After-Hours Care"/ OR exp "Night Care"/ OR exp "Day Care, Medical"/) AND (exp "Surgical Procedures, Operative"/ OR "su".fs OR "Surgical*".mp OR "surgery".mp OR exp "Postoperative Period"/ OR exp "Postoperative Care"/ OR exp "Perioperative Period"/ OR exp "Perioperative Care"/ OR exp "Perioperative Nursing"/ OR exp "Intraoperative Period"/ OR exp "Intraoperative Care"/ OR "acute care".mp) AND ("co".fs OR "complications".mp OR "complication".mp OR exp "Postoperative Complications"/ OR exp "Intraoperative Complications"/ OR exp "Urinary Catheters"/ae OR "postdischarge problems".mp OR "post discharge problems".mp OR "postdischarge adverse".mp OR "post discharge adverse".mp OR "ae".fs OR "retention bladder".mp OR exp "Urinary Retention"/ OR "urinary retention".mp OR "recatheterisation".mp OR "recatheterization".mp OR "recatheter*".mp) NOT (exp "Animals"/ NOT exp "Humans"/)) **OR** ((exp "Urinary Catheters"/ OR "Urinary Catheters".mp OR "Urinary Catheter".mp OR "Ureteral Catheter".mp OR "Ureteral Catheters". mp OR "Urethral Catheter".mp OR "Urethral Catheters".mp OR "urinary tract catheter".mp OR "urinary tract catheters".mp OR "foley catheter". mp OR "foley catheters".mp OR "folley catheter".mp OR ("urinary".mp AND ("catheter".mp OR "catheters".mp))) AND (exp *"Device Removal"/ OR "catheter removal".ti OR "removal of catheter".ti OR "removing catheters". ti OR "removal".ti OR "remov*".ti OR "removal practice".ti OR "removal practices".ti) AND (exp "Time"/ OR exp "Time Factors"/ OR "timing".mp OR "time".mp OR "evening".mp OR "morning".mp OR "midnight".mp OR "night". mp OR "early removal".mp OR "earlier removal".mp OR "early catheter removal".mp OR "earlier catheter removal".mp OR "early urinary catheter removal".mp OR "earlier urinary catheter removal".mp OR "late removal". mp OR "late catheter removal".mp OR "late urinary catheter removal".mp OR "early foley catheter removal".mp OR "late foley catheter removal". mp OR exp "After-Hours Care"/ OR exp "Night Care"/ OR exp "Day Care, Medical"/) AND (exp "Surgical Procedures, Operative"/ OR "su".fs OR "Surgical*".mp OR "surgery".mp OR exp "Postoperative Period"/ OR exp "Postoperative Care"/ OR exp "Perioperative Period"/ OR exp "Perioperative Care"/ OR exp "Perioperative Nursing"/ OR exp "Intraoperative Period"/ OR exp "Intraoperative Care"/ OR "acute care".mp) AND ("co".fs OR "complications".mp OR "complication".mp OR exp "Postoperative Complications"/ OR exp "Intraoperative Complications"/ OR exp "Urinary Catheters"/ae OR "postdischarge problems".mp OR "post discharge problems".mp OR "postdischarge adverse".mp OR "post discharge adverse".mp OR "ae".fs OR "retention bladder".mp OR exp "Urinary Retention"/ OR "urinary retention". mp OR "recatheterisation".mp OR "recatheterization".mp OR "recatheter*". mp) NOT (exp "Animals"/ NOT exp "Humans"/))**)**	218	1

c. Embase (Totaal d.d. 5-3-2021)	(((exp *"Urinary Catheter"/ OR "Urinary Catheters".ti OR "Urinary Catheter".ti OR "Ureteral Catheter".ti OR "Ureteral Catheters".ti OR "Urethral Catheter".ti OR "Urethral Catheters".ti OR "urinary tract catheter".ti OR "urinary tract catheters".ti OR "foley catheter".ti OR "foley catheters".ti OR "folley catheter".ti OR ("urinary".ti AND ("catheter".ti OR "catheters".ti))) AND (exp *"Device Removal"/ OR "catheter removal".ti,ab OR "removal of catheter".ti,ab OR "removing catheters".ti,ab OR "removal".ti,ab OR "remov*".ti,ab OR "removal practice".ti,ab OR "removal practices".ti,ab) AND (exp *"Time"/ OR exp *"Time Factor"/ OR "timing".ti,ab OR "time".ti,ab OR "evening".ti,ab OR "morning".ti,ab OR "midnight".ti,ab OR "night".ti,ab OR "early removal".ti,ab OR "earlier removal".ti,ab OR "early catheter removal".ti,ab OR "earlier catheter removal".ti,ab OR "early urinary catheter removal".ti,ab OR "earlier urinary catheter removal".ti,ab OR "late removal".ti,ab OR "late catheter removal".ti,ab OR "late urinary catheter removal".ti,ab OR "early foley catheter removal".ti,ab OR "late foley catheter removal".ti,ab OR exp *"Out-of-Hours Care"/ OR exp *"Night Care"/ OR exp *"Day Care"/) AND (exp *"Surgery"/ OR "su".fs OR "Surgical*".ti,ab OR "surgery".ti,ab OR exp *"Postoperative Period"/ OR exp *"Postoperative Care"/ OR exp *"Perioperative Period"/ OR exp *"Perioperative Care"/ OR exp *"Perioperative Nursing"/ OR exp *"Intraoperative Period"/ OR exp *"Intraoperative Care"/ OR "acute care".ti,ab) AND ("co".fs OR "complications".ti,ab OR "complication".ti,ab OR exp *"Postoperative Complication"/ OR exp *"Peroperative Complication"/ OR exp *"Urinary Catheter"/am OR exp *"Urinary Catheter"/ae OR "postdischarge problems".ti,ab OR "post discharge problems".ti,ab OR "postdischarge adverse".ti,ab OR "post discharge adverse".ti,ab OR "ae".fs OR "retention bladder".ti,ab OR exp *"Urine Retention"/ OR "urinary retention".ti,ab OR "recatheterisation".ti,ab OR "recatheterization".ti,ab OR "recatheter*".ti,ab) NOT (exp "Animals"/ NOT exp "Humans"/)) OR ((exp *"Urinary Catheter"/ OR "Urinary Catheters".ti,ab OR "Urinary Catheter".ti,ab OR "Ureteral Catheter".ti,ab OR "Ureteral Catheters".ti,ab OR "Urethral Catheter".ti,ab OR "Urethral Catheters".ti,ab OR "urinary tract catheter".ti,ab OR "urinary tract catheters".ti,ab OR "foley catheter".ti,ab OR "foley catheters".ti,ab OR "folley catheter".ti,ab OR ("urinary".ti,ab AND ("catheter".ti,ab OR "catheters".ti,ab))) AND (exp *"Device Removal"/ OR "catheter removal".ti OR "removal of catheter".ti OR "removing catheters".ti OR "removal".ti OR "remov*".ti OR "removal practice".ti OR "removal practices".ti) AND (exp *"Time"/ OR exp *"Time Factor"/ OR "timing".ti,ab OR "time".ti,ab OR "evening".ti,ab OR "morning".ti,ab OR "midnight".ti,ab OR "night".ti,ab OR "early removal".ti,ab OR "earlier removal".ti,ab OR "early catheter removal".ti,ab OR "earlier catheter removal".ti,ab OR "early urinary catheter removal".ti,ab OR "earlier urinary catheter removal".ti,ab OR "late removal".ti,ab OR "late catheter removal".ti,ab OR "late urinary catheter removal".ti,ab OR "early foley catheter removal".ti,ab OR "late foley catheter removal".ti,ab OR exp *"Out-of-Hours Care"/ OR exp *"Night Care"/ OR exp *"Day Care"/) AND (exp *"Surgery"/ OR "su".fs OR "Surgical*".ti,ab OR "surgery".ti,ab OR exp *"Postoperative Period"/ OR exp *"Postoperative Care"/ OR exp *"Perioperative Period"/ OR exp *"Perioperative Care"/ OR exp *"Perioperative Nursing"/ OR exp *"Intraoperative Period"/ OR exp *"Intraoperative Care"/ OR "acute care".ti,ab) AND ("co".fs OR "complications".ti,ab OR "complication".ti,ab OR exp *"Postoperative Complication"/ OR exp *"Peroperative Complication"/ OR exp *"Urinary Catheter"/am OR exp *"Urinary Catheter"/ae OR "postdischarge problems".ti,ab OR "post discharge problems".ti,ab OR "postdischarge adverse".ti,ab OR "post discharge adverse".ti,ab OR "ae".fs OR "retention bladder".ti,ab OR exp *"Urine Retention"/ OR "urinary retention".ti,ab OR "recatheterisation".ti,ab OR "recatheterization".ti,ab OR "recatheter*".ti,ab) NOT (exp "Animals"/ NOT exp "Humans"/))) NOT conference review.pt NOT (conference review or conference abstract).pt AND (conference abstract).pt	187	56

d. Web of Science (Totaal d.d. 5-3-2021)	((ti=("Urinary Catheter" OR "Urinary Catheters" OR "Urinary Catheter" OR "Ureteral Catheter" OR "Ureteral Catheters" OR "Urethral Catheter" OR "Urethral Catheters" OR "urinary tract catheter" OR "urinary tract catheters" OR "foley catheter" OR "foley catheters" OR "folley catheter" OR ("urinary" AND ("catheter" OR "catheters"))) AND ts=("Device Removal" OR "catheter removal" OR "removal of catheter" OR "removing catheters" OR "removal" OR "remov*" OR "removal practice" OR "removal practices") AND ts=("Time" OR "Time Factor" OR "timing" OR "time" OR "evening" OR "morning" OR "midnight" OR "night" OR "early removal" OR "earlier removal" OR "early catheter removal" OR "earlier catheter removal" OR "early urinary catheter removal" OR "earlier urinary catheter removal" OR "late removal" OR "late catheter removal" OR "late urinary catheter removal" OR "early foley catheter removal" OR "late foley catheter removal" OR "Out-of-Hours Care" OR "Night Care" OR "Day Care") AND ts=("Surgery" OR "Surgical*" OR "surgery" OR "Postoperative Period" OR "Postoperative Care" OR "Perioperative Period" OR "Perioperative Care" OR "Perioperative Nursing" OR "Intraoperative Period" OR "Intraoperative Care" OR "acute care") AND ts=("complications" OR "complication" OR "Postoperative Complication" OR "Peroperative Complication" OR "postdischarge problems" OR "post discharge problems" OR "postdischarge adverse" OR "post discharge adverse" OR "retention bladder" OR "Urine Retention" OR "urinary retention" OR "recatheterisation" OR "recatheterization" OR "recatheter*")) OR (ts=("Urinary Catheter" OR "Urinary Catheters" OR "Urinary Catheter" OR "Ureteral Catheter" OR "Ureteral Catheters" OR "Urethral Catheter" OR "Urethral Catheters" OR "urinary tract catheter" OR "urinary tract catheters" OR "foley catheter" OR "foley catheters" OR "folley catheter" OR ("urinary" AND ("catheter" OR "catheters"))) AND ti=("Device Removal" OR "catheter removal" OR "removal of catheter" OR "removing catheters" OR "removal" OR "remov*" OR "removal practice" OR "removal practices") AND ts=("Time" OR "Time Factor" OR "timing" OR "time" OR "evening" OR "morning" OR "midnight" OR "night" OR "early removal" OR "earlier removal" OR "early catheter removal" OR "earlier catheter removal" OR "early urinary catheter removal" OR "earlier urinary catheter removal" OR "late removal" OR "late catheter removal" OR "late urinary catheter removal" OR "early foley catheter removal" OR "late foley catheter removal" OR "Out-of-Hours Care" OR "Night Care" OR "Day Care") AND ts=("Surgery" OR "Surgical*" OR "surgery" OR "Postoperative Period" OR "Postoperative Care" OR "Perioperative Period" OR "Perioperative Care" OR "Perioperative Nursing" OR "Intraoperative Period" OR "Intraoperative Care" OR "acute care") AND ts=("complications" OR "complication" OR "Postoperative Complication" OR "Peroperative Complication" OR "postdischarge problems" OR "post discharge problems" OR "postdischarge adverse" OR "post discharge adverse" OR "retention bladder" OR "Urine Retention" OR "urinary retention" OR "recatheterisation" OR "recatheterization" OR "recatheter*"))) NOT ti=("veterinary" OR "rabbit" OR "rabbits" OR "animal" OR "animals" OR "mouse" OR "mice" OR "rodent" OR "rodents" OR "rat" OR "rats" OR "pig" OR "pigs" OR "porcine" OR "horse" OR "horses" OR "equine" OR "cow" OR "cows" OR "bovine" OR "goat" OR "goats" OR "sheep" OR "ovine" OR "canine" OR "dog" OR "dogs" OR "feline" OR "cat" OR "cats")	88	9

e. Cochrane (Totaal d.d. 5-3-2021)	((“Urinary Catheter” OR “Urinary Catheters” OR “Urinary Catheter” OR “Ureteral Catheter” OR “Ureteral Catheters” OR “Urethral Catheter” OR “Urethral Catheters” OR “urinary tract catheter” OR “urinary tract catheters” OR “foley catheter” OR “foley catheters” OR “folley catheter” OR (“urinary” AND (“catheter” OR “catheters”))):ti AND (“Device Removal” OR “catheter removal” OR “removal of catheter” OR “removing catheters” OR “removal” OR “remov*” OR “removal practice” OR “removal practices”):ti,ab,kw AND (“Time” OR “Time Factor” OR “timing” OR “time” OR “evening” OR “morning” OR “midnight” OR “night” OR “early removal” OR “earlier removal” OR “early catheter removal” OR “earlier catheter removal” OR “early urinary catheter removal” OR “earlier urinary catheter removal” OR “late removal” OR “late catheter removal” OR “late urinary catheter removal” OR “early foley catheter removal” OR “late foley catheter removal” OR “Out of Hours Care” OR “Night Care” OR “Day Care”):ti,ab,kw AND (“Surgery” OR “Surgical*” OR “surgery” OR “Postoperative Period” OR “Postoperative Care” OR “Perioperative Period” OR “Perioperative Care” OR “Perioperative Nursing” OR “Intraoperative Period” OR “Intraoperative Care” OR “acute care”):ti,ab,kw AND (“complications” OR “complication” OR “Postoperative Complication” OR “Peroperative Complication” OR “postdischarge problems” OR “post discharge problems” OR “postdischarge adverse” OR “post discharge adverse” OR “retention bladder” OR “Urine Retention” OR “urinary retention” OR “recatheterisation” OR “recatheterization” OR “recatheter*”):ti,ab,kw) OR ((“Urinary Catheter” OR “Urinary Catheters” OR “Urinary Catheter” OR “Ureteral Catheter” OR “Ureteral Catheters” OR “Urethral Catheter” OR “Urethral Catheters” OR “urinary tract catheter” OR “urinary tract catheters” OR “foley catheter” OR “foley catheters” OR “folley catheter” OR (“urinary” AND (“catheter” OR “catheters”))):ti,ab,kw AND (“Device Removal” OR “catheter removal” OR “removal of catheter” OR “removing catheters” OR “removal” OR “remov*” OR “removal practice” OR “removal practices”):ti AND (“Time” OR “Time Factor” OR “timing” OR “time” OR “evening” OR “morning” OR “midnight” OR “night” OR “early removal” OR “earlier removal” OR “early catheter removal” OR “earlier catheter removal” OR “early urinary catheter removal” OR “earlier urinary catheter removal” OR “late removal” OR “late catheter removal” OR “late urinary catheter removal” OR “early foley catheter removal” OR “late foley catheter removal” OR “Out of Hours Care” OR “Night Care” OR “Day Care”):ti,ab,kw AND (“Surgery” OR “Surgical*” OR “surgery” OR “Postoperative Period” OR “Postoperative Care” OR “Perioperative Period” OR “Perioperative Care” OR “Perioperative Nursing” OR “Intraoperative Period” OR “Intraoperative Care” OR “acute care”):ti,ab,kw AND (“complications” OR “complication” OR “Postoperative Complication” OR “Peroperative Complication” OR “postdischarge problems” OR “post discharge problems” OR “postdischarge adverse” OR “post discharge adverse” OR “retention bladder” OR “Urine Retention” OR “urinary retention” OR “recatheterisation” OR “recatheterization” OR “recatheter*”):ti,ab,kw)\	78	17

f. Emcare (Totaal d.d. 5-3-2021)	(((exp *"Urinary Catheter"/ OR "Urinary Catheters".ti OR "Urinary Catheter".ti OR "Ureteral Catheter".ti OR "Ureteral Catheters".ti OR "Urethral Catheter".ti OR "Urethral Catheters".ti OR "urinary tract catheter".ti OR "urinary tract catheters".ti OR "foley catheter".ti OR "foley catheters".ti OR "folley catheter".ti OR ("urinary".ti AND ("catheter".ti OR "catheters".ti))) AND (exp *"Device Removal"/ OR "catheter removal".ti,ab OR "removal of catheter".ti,ab OR "removing catheters".ti,ab OR "removal".ti,ab OR "remov*".ti,ab OR "removal practice".ti,ab OR "removal practices".ti,ab) AND (exp *"Time"/ OR exp *"Time Factor"/ OR "timing".ti,ab OR "time".ti,ab OR "evening".ti,ab OR "morning".ti,ab OR "midnight".ti,ab OR "night".ti,ab OR "early removal".ti,ab OR "earlier removal".ti,ab OR "early catheter removal".ti,ab OR "earlier catheter removal".ti,ab OR "early urinary catheter removal".ti,ab OR "earlier urinary catheter removal".ti,ab OR "late removal".ti,ab OR "late catheter removal".ti,ab OR "late urinary catheter removal".ti,ab OR "early foley catheter removal".ti,ab OR "late foley catheter removal".ti,ab OR exp *"Out-of-Hours Care"/ OR exp *"Night Care"/ OR exp *"Day Care"/) AND (exp *"Surgery"/ OR "Surgical*".ti,ab OR "surgery".ti,ab OR exp *"Postoperative Period"/ OR exp *"Postoperative Care"/ OR exp *"Perioperative Period"/ OR exp *"Perioperative Care"/ OR exp *"Perioperative Nursing"/ OR exp *"Intraoperative Period"/ OR exp *"Intraoperative Care"/ OR "acute care".ti,ab) AND ("complications".ti,ab OR "complication".ti,ab OR exp *"Postoperative Complication"/ OR exp *"Peroperative Complication"/ OR "postdischarge problems".ti,ab OR "post discharge problems".ti,ab OR "postdischarge adverse".ti,ab OR "post discharge adverse".ti,ab OR "retention bladder".ti,ab OR exp *"Urine Retention"/ OR "urinary retention".ti,ab OR "recatheterisation".ti,ab OR "recatheterization".ti,ab OR "recatheter*".ti,ab) NOT (exp "Animals"/ NOT exp "Humans"/)) OR ((exp *"Urinary Catheter"/ OR "Urinary Catheters".ti,ab OR "Urinary Catheter".ti,ab OR "Ureteral Catheter".ti,ab OR "Ureteral Catheters".ti,ab OR "Urethral Catheter".ti,ab OR "Urethral Catheters".ti,ab OR "urinary tract catheter".ti,ab OR "urinary tract catheters".ti,ab OR "foley catheter".ti,ab OR "foley catheters".ti,ab OR "folley catheter".ti,ab OR ("urinary".ti,ab AND ("catheter".ti,ab OR "catheters".ti,ab))) AND (exp *"Device Removal"/ OR "catheter removal".ti OR "removal of catheter".ti OR "removing catheters".ti OR "removal".ti OR "remov*".ti OR "removal practice".ti OR "removal practices".ti) AND (exp *"Time"/ OR exp *"Time Factor"/ OR "timing".ti,ab OR "time".ti,ab OR "evening".ti,ab OR "morning".ti,ab OR "midnight".ti,ab OR "night".ti,ab OR "early removal".ti,ab OR "earlier removal".ti,ab OR "early catheter removal".ti,ab OR "earlier catheter removal".ti,ab OR "early urinary catheter removal".ti,ab OR "earlier urinary catheter removal".ti,ab OR "late removal".ti,ab OR "late catheter removal".ti,ab OR "late urinary catheter removal".ti,ab OR "early foley catheter removal".ti,ab OR "late foley catheter removal".ti,ab OR exp *"Out-of-Hours Care"/ OR exp *"Night Care"/ OR exp *"Day Care"/) AND (exp *"Surgery"/ OR "Surgical*".ti,ab OR "surgery".ti,ab OR exp *"Postoperative Period"/ OR exp *"Postoperative Care"/ OR exp *"Perioperative Period"/ OR exp *"Perioperative Care"/ OR exp *"Perioperative Nursing"/ OR exp *"Intraoperative Period"/ OR exp *"Intraoperative Care"/ OR "acute care".ti,ab) AND ("complications".ti,ab OR "complication".ti,ab OR exp *"Postoperative Complication"/ OR exp *"Peroperative Complication"/ OR "postdischarge problems".ti,ab OR "post discharge problems".ti,ab OR "postdischarge adverse".ti,ab OR "post discharge adverse".ti,ab OR "retention bladder".ti,ab OR exp *"Urine Retention"/ OR "urinary retention".ti,ab OR "recatheterisation".ti,ab OR "recatheterization".ti,ab OR "recatheter*".ti,ab) NOT (exp "Animals"/ NOT exp "Humans"/)))	26	1
g. Additional records (Totaal d.d. 23-7-2021)	The reference and citation search	83	50
Total		908	362

Chapter 5
De-implementation of urinary catheters in neurosurgical patients during the operation and on the ward:
a mixed-methods multicentre study protocol

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Abstract

Background
Indwelling urinary catheters (IDUCS) are routinely inserted during transsphenoidal pituitary gland tumour surgery or spinal fusion surgery, despite literature stating that there are no indications for using IDUCS during or following these surgeries. The aim of the study is to reduce the number of inappropriately inserted IDUCS during or post transsphenoidal pituitary gland tumour surgery and spinal fusion surgery with an operation time of less than 4 hours.

Methods
A pragmatic, before-and-after mixed-methods observational study was initiated in a multicentre neurosurgical context. This study includes medical chart analysis, satisfaction surveys with patients and healthcare professionals, and multidisciplinary group interviews to assess the effectiveness of, and experiences with, a multifaceted non-invasive de-implementation strategies The study has a timespan of 2.5 years starting in 2020.

Discussion
This paper presents the study protocol of a multi-centred before and after trial that aims to reduce inappropriate IDUC use after transsphenoidal pituitary gland tumour surgery and spinal fusion surgery, thereby reducing UTIs, shortening length of hospital stay, and increasing patient comfort. The results can be used to de-implement IDUCS after a broad range of surgeries on several wards.

Trial registration
The study has been submitted to the Dutch Trial Register (NTR).

Background

Indwelling urinary catheter (IDUC) placement in instances of neurosurgical interventions such as anterior skull base operations (e.g. transsphenoidal resection of pituitary gland tumours) and spinal fusion operations (spondylodesis) has become standard practice for various reasons (1, 2). In patients where an IDUC was not placed during surgery, these will frequently be inserted upon their return at the recovery room or the neurosurgical ward.
Current literature highlights a distinction between appropriate and inappropriate IDUC use in daily practice. The following reasons are generally viewed as appropriate:
- Urinary retention and obstruction of the bladder (3);
- Surgery time > 4 hours (4);
- Mobility restriction ≥ 24 hours postoperative (3);
- Administration of large contents of infusion fluid and/or diuretics during operation (3);
- The need to measure the urine production every hour postoperative (5).

Despite abovementioned appropriate reasons for IDUC placement, there are a number of arguments to be made against IDUC use including prolonged recovery time and increased health risks of a different nature. It is commonly known that IDUCS are associated with urinary tract infections (UTIs), non-infection complications (e.g. pain, discomfort, haematuria, mobility restriction and the feeling the need to urinate) and delayed mobilization (6). UTIs need to be treated with antibiotics which can lead to antibiotic

resistance (7, 8), and cases of hospital acquired UTIs are associated with longer hospital stay and additional costs (9). The restriction on a patient's ability to mobilize due to the IDUC prolongs their recovery time as research shows that early mobilization postoperatively decreases the risk complications and morbidity (e.g. respiratory decompensation/ pneumonias, deep venous thrombosis/pulmonary embolism) (10). If an IDUC is inserted pre- or postoperatively, literature, regardless of the surgical diagnosis, indicates that IDUCS should be removed promptly, preferably within 24-hours postoperatively. This is due to the fact that with every extra day an IDUC remains in place, the patient risk for developing a urinary tract infection increases by 3-7% (3, 11). However, it is unknown to what extent IDUCS are removed within this 24-hour timeframe after transsphenoidal resection of pituitary gland tumours and spinal fusion operations.
The decision to insert an IDUC pre- and postoperative transsphenoidal resection of pituitary gland tumours and spinal fusion operations, is based on a number of considerations including but not limited to: the detection of the post-surgical complications diabetes insipidus (DI), post-operative mobility restriction (maximum 24-hours), urinary retention, and convenience for nurses when a patient has an IDUC.

Diabetes insipidus
The key argument in favour of IDUC placement is that it helps ensure close monitoring of fluid balance, which is key to early detection and diagnosis of the most common postoperative complication after pituitary surgery is diabetes insipidus. This condition is characterized by polydipsia and polyuria and can lead to dehydration when left undetected (12). Although IDUCS are known to increase accuracy with regards to measurement of fluid output, hourly measurement of the fluid balance postoperatively, which is indicated an appropriate indication for IDUC use, is not a requirement (13). Monitoring the fluid balance closely every 6-12 hours following transsphenoidal pituitary surgery is sufficient for ensuring early detection and diagnosis of diabetes insipidus (DI) (2, 14, 15). The absence of additional risk of fluid disturbance following spondylodesis operations reduces the need to monitor fluid balance postoperatively (16).

Mobility restriction
In general, postoperative mobilisation restriction occurs only in rare instances following transsphenoidal resection of pituitary gland tumours and spondylodesis operations, and the duration of the bedrest generally does not exceed the twenty-four hour limit, which is the cut-off-point for an appropriate IDUC indication (3, 4, 15, 17-20).

Urinary retention
Another common reason IDUCS are inserted postoperatively is due to post-operative urinary retention (POUR). Urinary retention is the inability to empty the bladder despite being full (21). POUR is common following anesthesia and surgery without IDUC placement, with reported incidence of 5% – 70% after general surgery and up to 50% after spinal surgery (22, 23). Despite POUR being indicated as an appropriate reason for IDUC insertion, intermittent catheterization has been described in literature as preferred intervention due to a lower risk of UTIs (3).

Convenience
IDUCS are frequently inserted after surgery due to convenience of care for nurses, especially after pituitary surgery where one of the main tasks for nurses is to monitor the fluid balance (24). IDUCSS reduce nurses' workload as there is no need to mobilize patient to the restroom and collect the urine in bedpans (25).

Alternatives
Instead of inserting an IDUC without an appropriate reason, the urinary output can be collected and measured with the aid of non-invasive, lower risk tools including an urinal or bedpan (20). When a patient is unable to urinate postoperatively, bladder scanners can help assess the urinary retention after which intermittent catheterization can be executed (26).
Since IDUCS might be used to a greater extent and possibly for a longer period than is deemed appropriate by literature following these surgeries, this protocol describes a study to evaluate the effectiveness of multiple de-implementation strategies to reduce the inappropriate use of IDUCS during the operation and in the postoperative phase on the ward. Therefore, the goal of this study is*: "no IDUC, unless…"*

Methods

Design

This pragmatic, mixed-methods observational study collects medical chart data, satisfaction survey data and multidisciplinary group interviews data to assess the effectiveness of and experiences with various non-invasive de-implementation strategies aimed at decreasing the number of inappropriate IDUCS inserted during and after transsphenoidal pituitary gland tumour surgery and spinal fusion surgery in a multicentre context. The study has a before-and-after design and a timespan of 2.5 years starting in 2020. The medical chart assessment continues throughout the entire duration of the study whereas the satisfaction surveys and group interviews take place both before and after the de-implementation strategies are implemented. The surveys will be held with both patients and healthcare professionals whereas the group interviews will involve healthcare professionals only. Quantitative methods are used to assess the effect of the de-implementation strategies on IDUC related outcomes including IDUC placement, complications and patients' and healthcare professionals' experiences. The group interviews are used to gather insight into the role of each specific professional regarding IDUC use in the patients' journey from pre-operative consult to discharge.

We have six specific aims:
- To reduce the number of inappropriate inserted IDUCS in the hospital during and after transsphenoidal pituitary gland tumour surgery and spinal fusion surgery with an operation time of less than 4 hours;
- To assess the frequency of intermitted urinary catheterization after transsphenoidal pituitary gland tumour surgery and spinal fusion surgery;
- To reduce the number of UTIs following transsphenoidal pituitary gland tumour surgery and spinal fusion surgery;
- To assess the number of urinary retention bladders in relation to the number of IDUCS placed during and after transsphenoidal pituitary gland tumour surgery and spinal fusion surgery;
- To better understand patients' experiences and to provide a broad understanding of potential factors contributing to patient satisfaction in relation to urinating in the postoperative phase;
- To investigate healthcare professionals' experiences with IDUCS and the experienced consequences after IDUC de-implementation.

Setting
This is a multicenter study and will take place in one university hospital in which both transsphenoidal pituitary gland tumour surgery and spinal fusion surgery are executed, and four general hospitals where only spinal fusion surgery is performed. The multifaceted de-implementation strategies will be implemented in four intervention hospitals: the university hospital and three general hospitals. One general hospital is designated for the control group since, according to the hospitals' neurosurgeons, IDUCS are not routinely placed in this hospital. All hospitals are located in the Randstad, which is the most densely populated area in the Netherlands and selected based on the following criteria: 1. transsphenoidal pituitary gland tumour surgery and spinal fusion surgery is executed and 2. IDUC use is routinely reported in the medical chart.

Study population
The study population consists of two groups: 1. patients who underwent/will undergo transsphenoidal pituitary gland tumour surgery or spinal fusion surgery and 2. healthcare professionals (e.g. neurosurgeons, neurosurgical residents, operation assistants, recovery nurses, neurosurgical ward nurses). All patients who underwent transsphenoidal pituitary gland tumour surgery or spinal fusion surgery in 2019 and 2020, and are aged 18 and older, are included in the medical chart assessment. Patients who will undergo transsphenoidal pituitary gland tumour surgery or spinal fusion surgery in 2021 or 2022, and are aged 18 and older, are eligible for the study and have to give consent for the medical chart assessment and survey. Patients who meet any of the following criteria will be excluded from participation: an operation time > 4 hours; having a mobility restriction ≥ 24 hours postoperative, having pre-existing bladder complications for which an IDUC is used pre-operatively; peri- or postoperative neurological deficit (e.g. paresis, paralysis); having pre-existing psychological problems; being unable to understand and/or execute instructions from healthcare professionals and not speaking fluent Dutch or English fluently. If patients are underwent surgery in 2021 or 2022 and informed consent is not obtained for the medical chart assessment or the survey, they will be excluded from the study.

Healthcare professionals working as neurosurgeons, neurosurgical residents, operation assistants, recovery nurses or neurosurgical ward nurses are eligible for participation in the survey and group interviews. All participants must be aged 18 or older and provide consent to participate. Healthcare professionals who do not give consent for the survey and/or the group interviews are excluded from the study.

Main outcome
The primary study parameter is the number of IDUCS that are placed during and after transsphenoidal pituitary gland tumour surgery and spinal fusion surgery (spondylodesis).

Secondary outcomes
Secondary outcomes linked to the medical chart assessment are:
- incidence of intermittent urinary catheterization,
- incidence and volume of urinary retention bladders,
- incidence of urinary tract infections.

Secondary outcomes from the patients' surveys are the postoperative experiences with and without IDUC use and the implications for the recovery process. Outcomes related to healthcare surveys are experiences with postoperative IDUC use and the conse-

quences of de-implementing IDUCS. Secondary outcomes related to the group interviews are perceptions on the role of each specific professional regarding IDUC use in the patients' journey from pre-operative consult to being discharged.

Medical chart assessment

During the pre-operative consult, patients will be asked to participate in the study, thereby participating in the medical chart assessment, by the nurse or resident who attends the consult. The following items will be systematically collected from each medical record:

- The incidence of IDUC placement, including date of insertion, time of placement, location of insertion, reason of insertion and which discipline inserted the IDUC;
- The incidence of intermitted urinary catheterization, including date and time of insertion, location of insertion, reason of insertion and which discipline inserted the catheter;
- The incidence and volume of urinary retention bladders, including: date of urinary retention and where the urinary retention was noticed. We defined a retention bladder as a urine volume of more than 500 milliliter (ml) (27);
- The incidence of urinary tract infections. The diagnosis of a symptomatic urinary tract infection, with or without an IDUC, is the detection of bacteria and leukocytes in the presence of clinical symptoms (28). This definition is chosen since asymptomatic urinary tract infections can be expected when testing urine from an IDUC without the presence of symptoms and do not require antibiotic therapy (29). Clinical symptoms include painful and frequent urination, fever, flank pain and general malaise (30). The pathogen and leukocytes are detected and identified by using midstream urine for a urine sediment. The sediment must contain >103 cfu/mL bacteria and >5 leukocytes (28, 31);
- The operation time in minutes;
- The duration of stay in recovery room in minutes;
- The date of operation;
- Age;
- Gender;
- Length of hospital stay in days;

Data is stored in Castor EDC.

Satisfaction surveys

The patient satisfaction survey will be designed to gather insight into patient experiences postoperatively and to provide a broad understanding of potential factors contributing to patient satisfaction in relation to urinating in the postoperative phase. The healthcare professional satisfaction survey will be designed to acquire a greater understanding of healthcare professionals' experiences with IDUCS and the experienced consequences after IDUC de-implementation. Both surveys will be tested by pilot participants selected from the neurosurgical ward and the operation room. After piloting and revision, the surveys will be sent to all eligible healthcare professionals via their work-email in the before and after measurement phase. During the pre-operative consult, patients will be asked to participate in the survey by the nurse or resident who attends the consult. Patients will receive a hardcopy of the survey if they are admitted to the hospital.

Group interviews
A purposive sampling method will be used to create a diverse and representative sample of at least one professional from each profession. Healthcare professionals will be asked to participate in the focus group via their work e-mail. The participants are all working in one of the five hospitals and there will be no mixing between hospitals as policies and procedures can differ per site. The group interviews will be held at a date and place most suitable for the participants in a meeting room in the specific hospital. The group interview will focus on the following topics: 1. participants' experiences with the current IDUC policy per- and postoperatively, 2. perceptions and experiences with intercollegiate collaboration and communications regarding IDUC use and 3. perceptions regarding the patients' role. In addition, demographics including information on age, working experience and gender will be collected at the beginning of the group interviews. The interviews will be led by an independent moderator. At least one of the researchers will also attend the group interviews to answer specific questions related to the topics. The expected duration of the interviews is 60 – 80 minutes. The interviews will be taped and transcribed verbatim.

De-implementation strategies
In this study, multifaceted de-implementation strategies will be used to decrease the number of inserted IDUCS in pituitary and spinal fusion patients. The de-implementation strategies focus primarily on healthcare professionals. The rationale behind using multiple strategies is that the components positively influence one another and add to acquiring the wanted effect (32). The de-implementation strategies will take place in the four intervention hospitals. There will be no strategies implemented in the control hospital.

Flowcharts
Three flowcharts (figure 1, 2 and 3) were created based on the indications for appropriate IDUC use in combination with the treatment of POUR. The flowcharts advocate intermittent catheterization over inserting an IDUC, as this intervention has a lower risk of UTIs (3). A bladder scanner can be used if a patient is unable to urinate to detect the urinary retention (26). Based on literature and the hospitals' urinary retention policy, we used 500 ml urine in the bladder as cut-off-point for intermittent catheterization and 100 ml in the bladder as post-void residual (33, 34).
Flowchart 1 is designed to use during prior to the operation when deciding on IDUC placement.

Flowchart 2 can be used in the recovery room and helps determine actions necessary when a patient is unable to urinate.

Figure 1: Flowchart IDUC placement during surgery

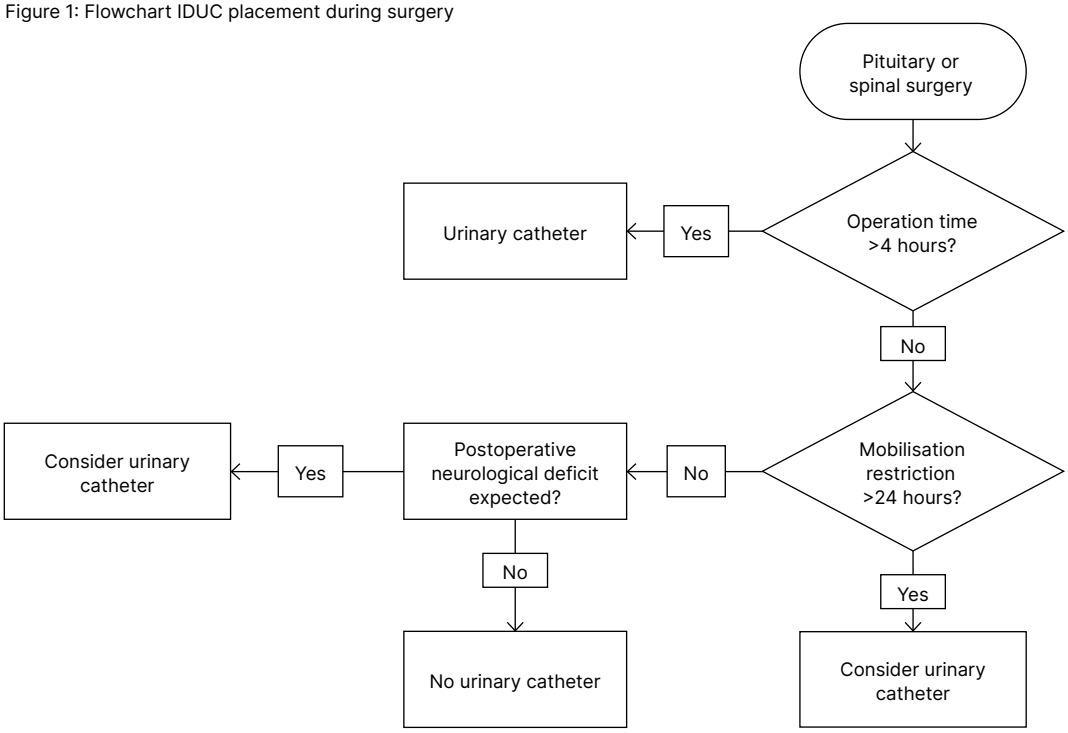


Figure 2: Flowchart IDUC placement in the recovery room

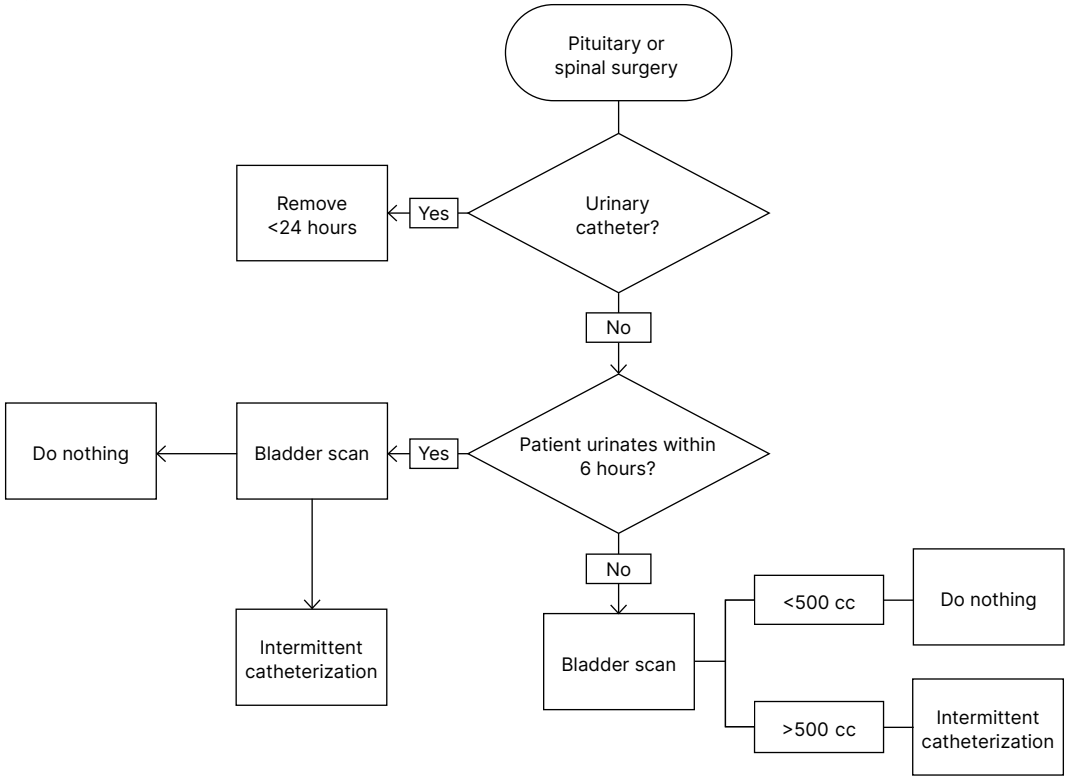
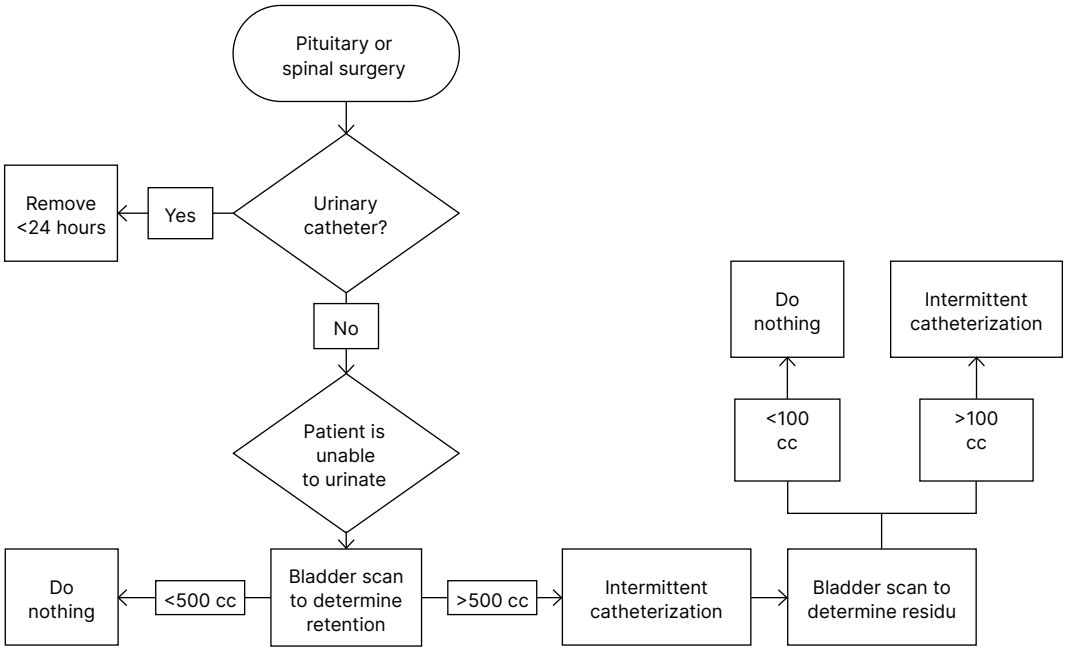


Figure 3: Flowchart IDUC placement in neurosurgical ward



Education
Neurosurgeons, neurosurgical residents, operation assistants, recovery nurses and neurosurgical ward nurses will receive education regarding appropriate and inappropriate IDUC use during and after pituitary and spondylodesis surgery. The information sessions consist of a presentation delivered by the researcher and will take place once at each intervention hospital . Figures 1, 2 and 3 will be used as basis for the educational programme. Additionally, the importance of reducing IDUC use as well as possible complications will be discussed. Healthcare professionals will receive information on how to document IDUC use comprehensively and thoroughly (e.g. date and time of insertion, location of insertion, reason of insertion, which discipline inserted the IDUC, date and time of urinary retention and volume of urinary retention) in the medical chart.

Information
Information regarding the existence of the study will be distributed among the healthcare professionals in the hospitals to create awareness. Intranet, social media and hospital newsletters will be used for dissemination.

Reminders
Informational posters regarding (in)appropriate IDUC use will be placed in the breakrooms of the operation theatre, neurosurgical residents and on the neurosurgical ward.
Organizational strategies
To ensure a structural change in IDUC use, the new policy will be established in the formal and informal rules of each hospital. This means that procedures and protocols regarding inserting an IDUC will be changed.

Feedback
The outcome measures of the collected data regarding IDUC at baseline and after measurements will be communicated to each hospital during the study once per month by sending newsletters to participating healthcare professionals.

Patient information
During the pre-operative consult with the neurosurgeon, all patients will receive information regarding the use of an IDUC during and after the surgery. Patients will receive an infographic explaining the reason for IDUC reduction including alternatives use.

Sample size
In the academic hospital, approximately 150 patients undergo a transsphenoidal pituitary gland tumour surgery per year. In all five hospitals combined, approximately 657 patients undergo a spinal fusion surgery (spondylodesis) per year. The duration of the study is 2.5 years which means that the medical charts of a total of 375 pituitary patients and 1643 spondylodesis patients can be included in the study.

Patients will be asked to fill in the patient satisfaction survey for a period of two months during the basement measurement period as well as in the after measurement period. Per month, 12-13 patients will undergo pituitary surgery. Therefore, a total of 48 – 52 pituitary patients will be asked to participate in the survey. In the hospitals combined, 55 patients will have a spondylodesis operation every month, which means that over a period of four months 219 patients will be asked to fill in the survey.

For all five hospitals combined, there are 650 healthcare professionals who are involved in the care for pituitary and/or spondylodesis patients. These participants will be asked to participate in a satisfaction survey at baseline measurement as well as the after measurement. Group interviews will be held in each intervention hospital in the baseline and after measurement phase. The group interviews will consist of six to eight participants as literature indicates that this number is sufficient (35). Per hospital 12-16 healthcare professionals will be asked to participate. In total, 60 to 80 healthcare professionals will be asked to participate in the group interviews.

Analysis
We used a combination of qualitative and quantitative data to answer the primary and secondary outcomes. The medical chart research and the satisfaction surveys will be analysed using quantitative techniques while the group interviews will be analysed with the aid of qualitative methods. A deletion method will be used to eliminate missing data.

Primary outcome
The primary study parameter will be the number of IDUCS that are placed during and/or after transsphenoidal pituitary gland tumour surgery and spinal fusion surgery (spondylodesis). The number of inappropriately/appropriately placed IDUCS will be determined with the aid of figures 1, 2 and 3. The software programme SPSS is used during the analysis. The data will be analysed for all hospitals combined with a logistic regression with corrections for several baseline characteristics of the population (e.g. age, sex, type of operation, hospital and COVID-19 period). Data corresponding with the IDUC placement (e.g. date of insertion, time of placement, location of insertion, reason of insertion and which discipline inserted the IDUC) will be analysed with descriptive statistics. The data will be analysed per hospital with the aid of descriptive statistics.

Continuous data will be presented as median (interquartile range) or mean (standard deviation) and where appropriate categorical variables as number (percentages). Graphic data displays may also be used to summarize the data. Descriptive statistics will also be presented for the baseline measurement and the after measurement separately.

Since the control hospital states that there a no IDUCS inserted during/after spondylodesis operations prior to the study, the extent to which the data from this hospital can be incorporated in the analysis will be determined after the baseline measurement. If there are (almost) no IDUCS inappropriately placed, the data will only be analysed with descriptive statistics. The data will be incorporated in the logistic regression if IDUCS are frequently inappropriately inserted.

Secondary outcome

Medical chart

The incidence of intermittent urinary catheterization, the incidence of urinary retention and the incidence of urinary tract infections will be analyzed equally to the primary study parameter.

Surveys

The surveys from the healthcare professionals will be analyzed with the aid of a paired non-parametric T-test. The surveys from the patients will be analyzed with a non-paired non-parametric test. Demographics will be analyzed with descriptive statists.

Group interviews

Following transcription of the interviews, the software program Atlas.ti will be used to analyze the data. The grounded theory will be used as a framework for the analysis (36, 37). This analysis involves three sequential phases of coding: open, axial and selective coding (38). An iterative approach was used which implies that data collection and analysis occurred simultaneously (39, 40). Two researchers will independently code the transcripts and afterwards discuss the findings to reach consensus about the interpretation.

Ethics and funding

Approval from the Ethical Committee was obtained for all five hospitals either at site level or, where this did not exist, from a scientific committee at the site. The researchers will adhere to ethical standard for research involving people. Additionally, all researchers will follow their institutional ethical requirements. Funding sources did not partake in the writing of this manuscript or the decision to submit the publication. Patients and healthcare professionals will be given an informed consent form as well as information on the study and the participants rights, prior to the operations, the surveys and the group interviews,. It will be specifically stated that participation is voluntary, that participants can withdraw at any time, and that confidentiality is guaranteed through anonymization. Per request, the results of the study will be communicated to the participants by email.

Discussion

This paper presents the study protocol of a multi-centred before and after trial that aims to reduce inappropriate IDUC use after transsphenoidal pituitary gland tumour surgery and spinal fusion surgery, thereby reducing UTIs, shortening hospital stay and increasing patient comfort. Besides developing and executing de-implementation strategies to

accomplish a reduction of used IDUCS, the study focusses on patient and healthcare professional experiences with IDUCS in daily practice and the consequences for the care system. Several challenges are anticipated while executing the study. Since this is a study executed in five hospitals, frequent and clear communication between the researchers and the different departments in each hospital is needed. Additionally, in light of busy schedules of our professionals, planning the group interviews ahead is necessary to ensure a sufficient number of participants. The results from this study can be used to de-implement IDUCS after a broad range of surgeries on several wards.

Contributions to the literature

The implementation of a variety of de-implementation strategies focussed on the healthcare professional as well as patients on reducing indwelling urinary catheter use and its complications;

A greater understanding of patients' experiences with urinating after transsphenoidal resection of pituitary gland tumours and spinal fusion operations;

Facilitates multidisciplinary discussion on the use of IDUCS in the postoperative phase.

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Chapter 6
Improving postoperative care for neurosurgical patients by a standardized protocol for urinary catheter placement: a multicentre before-and-after implementation study

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Abstract

Introduction
Urinary catheterization, including indwelling and clean intermittent catheterization, is common in peri- and postoperative care. Despite guidelines, practice variation is significant. Inappropriate catheterization risks include urinary tract infections and reduced mobility, leading to prolonged hospital stays and increased antibiotic use. This study aims to improve postoperative care through appropriate catheterization in neurosurgical groups frequently subjected to catheterization.

Methods
We conducted a multicentre, before-and-after study in four Dutch hospitals from June 2021 to January 2023, including adult neurosurgical patients who underwent pituitary gland tumour or spinal fusion surgery. Exclusion criteria included conditions requiring chronic catheter use. A multifaceted strategy was implemented, focusing on a uniform protocol, an educational program, and department-specific champions. Primary outcome was inappropriate catheterization, analysed with ordinal logistic regression. Secondary outcomes included total catheterizations, urinary tract infections, and length of hospital stay. Ethical approval was obtained. STROBE and SQUIRE checklists were used.

Results
Among 3,439 patients screened, 2,711 were included, with 544 in the after group. The percentage of patients without inappropriate indwelling catheterization increased from 46% to 57%, and the proportion without inappropriate clean intermittent catheterization rose from 34% to 67%. Additionally, overall catheter use decreased: the percentage of patients not receiving an indwelling catheter increased from 54% to 64%, while those not requiring clean intermittent catheterization rose from 89% to 92%. Infection rates and hospital stay were similar (1.4% and 1.3%; 4.9 and 5.1 days, respectively).

Conclusions
Implementing a uniform protocol may significantly reduce inappropriate and overall catheterization in neurosurgical patients, aligning with patient-centred, less invasive healthcare. Ongoing education and adherence to standardized protocols are crucial. Future research should assess the long-term sustainability of these strategies.

What is already known on this topic
Urinary catheterization, including indwelling urinary catheterization (IDUC) and clean intermittent catheterization (CIC), is commonly used in peri- and postoperative care. Despite international guidelines, there is considerable variation in practice, leading to inappropriate catheterization and associated risks such as urinary tract infections, pain, and prolonged hospital stays.

What this study adds
This study demonstrates that a multifaceted strategy, including the implementation of a uniform catheter protocol and an educational program, can significantly reduce inappropriate and overall catheter use in neurosurgical patients. It also highlights the importance of department-specific champions in improving adherence to standardized protocols.

How this study might affect research, practice, or policy
The findings underscore the potential of standardized protocols and continuous edu-

cation in enhancing patient care and reducing unnecessary medical interventions. This approach could be applied to other areas of healthcare to promote patient-centred, less invasive practices and improve overall healthcare quality.

Introduction

In peri- and postoperative care settings, urinary catheterization, which includes both indwelling urinary catheterization (IDUC) and clean intermittent catheterization (CIC), is a commonly used nursing intervention. International guidelines provide distinctions between appropriate and inappropriate indications for IDUC and CIC for healthcare settings across the continuum of care. (1) These indications include conditions, such as postoperative urinary retention, post-void residual, prolonged surgery, and prolonged bed rest. (1, 2) Postoperative urinary retention is defined as the patient's inability to void, while post void-residual refers to the volume of urine remaining in the bladder after urination. (3) An extended duration of surgery is an additional indication for IDUC, primarily to prevent potential incontinence or overdistention of the bladder due to large volumes of intravenous fluids administered during anaesthesia and to monitor fluid balance on an hourly basis. (1)

Despite these distinct indications in the guidelines, a significant challenge arises from the lack of clarity regarding the specific thresholds for peri- and postoperative urinary retention, post-void residual, prolonged postoperative bed rest, and operation duration in urinary catheterization protocols that necessitate IDUC or CIC. (4, 5) This ambiguity has led hospitals to often adopt their own protocols, resulting in different thresholds between institutions. In addition, previous research has identified several other causes for inappropriate catheterization, including inconsistent adherence to guidelines, variability in clinical decision-making, and inadequate staff training, further contributing to the inconsistency in clinical practice. (6, 7)

Given the inherent risks associated with IDUC and CIC, it is crucial to minimize their use to enhance the quality of patient care. Among these risks, urinary tract infections (UTIs) frequently occur: IDUC elevates infection rates by 5 to 10% for each day of use, while the CIC infection rates range from 0.5 to 20% per catheterization event. (8) Non-infectious complications also occur, including pain, discomfort, and haematuria, which can reduce patient mobility. (9, 10) These risks not only lead to increased antibiotic consumption but could also result in prolonged hospital stays. (11)

Extensive research has focused on minimizing both general and unnecessary catheterization across various healthcare settings, such as intensive care units, emergency rooms, general wards, and nursing homes. (12, 13) However, such efforts have not been applied in the field of neurosurgery. This gap is critical, given the routine practice of catheterization in the postoperative care of neurosurgical patients, such as those undergoing surgeries for pituitary gland tumours or spinal fusion. (14, 15) These particular neurosurgical patient groups are of interest because of the relatively short duration of their surgeries, usually 2 to 4 hours, and the standard procedure encouraging early postoperative mobilization, provided there are no complications like cerebrospinal fluid leakage. (16)

Considering the challenges stemming from the absence of standardized practices and thresholds, combined with the identified risks of inappropriate catheterization, these

two patient cohorts provide a unique context for studying the reduction of inappropriate use, and refinement of standardized practices with respect to IDUC and CIC. The aim of this study is to improve postoperative care through accurate IDUC and CIC in patients who underwent pituitary gland tumour and spinal fusion surgery.

Methods

Design and setting

We conducted a multicentre before-and-after study in four hospitals (one university hospital, two large teaching hospitals and one general hospital) to analyse clinical outcomes following the introduction of a multifaceted strategy aimed at reducing inappropriate peri- and postoperative IDUC and CIC. Before data was collected from 2018 to 2021. The strategy was introduced from January 1, 2022, to May 30, 2022. Data for the after period was collected from June 1, 2022, to December 31, 2022. To enhance the clarity and transparency of our study reporting, we utilized the STROBE and SQUIRE checklists. (17, 18)

Population

Adult patients admitted to the neurosurgical wards who underwent either transsphenoidal pituitary gland tumour surgery or spinal fusion surgery under general anaesthesia were considered for inclusion. Patients were categorized into three groups based on the type of surgery performed: 1. Pituitary surgery, 2. Spondylodesis, and 3. Trauma or tumour debulking. Patients were excluded based on the following criteria: (a) presence of a suprapubic catheter, (b) chronic IDUC or CIC prior to hospital admission, (c) first IDUC in another hospital/long-term care facility, (d) first IDUC in an emergency department, (e) IDUC or CIC according to spinal cord injury (paraplegic) protocol and (f) transfer to intensive care unit or hospice care.

Data collection

Data were collected from June 2021 to January 2023 through medical record review. This process was tailored to institutional preferences, allowing for either remote or on-site data gathering. The primary researcher, in collaboration with three nurses and a research assistant, extracted data pertaining to patients' clinical trajectories and complications during their hospital stay. This included information related to IDUC, CIC, urinary retention, urinary residuals, and urinary tract infections sourced from both medical and nursing records. Data on surgical duration were collected and defined as the time from anaesthesia induction to the patient's return to the recovery room. Antibiotic prophylaxis was not part of the study protocol, and data on antibiotic use in participating hospitals were not systematically recorded. To ensure data integrity, the primary researcher and nursing team routinely cross-checked the recorded data. The primary researcher aided in cases of ambiguity or missing information in the medical records. Uncertainties were discussed and, if necessary, a second researcher was consulted. Additionally, to ensure quality control, the second researcher reviewed the data on three separate occasions during the data collection process.

Multifaceted strategy

To standardize care and reduce variability in clinical decisions across different hospitals, we developed a uniform protocol for IDUC, CIC, and urinary tract infections within the surgical department, recovery unit, and neurosurgical nursing ward. This protocol established clear definitions for appropriate and inappropriate practices, aiming to guide

clinical decision-making. The content of the newly established protocol was formulated based on protocols used in the academic hospital, relevant international and national guidelines and was validated by two independent urologists from the academic hospital. (5, 19) The protocol specified that IDUCS were deemed inappropriately placed under the following conditions: (a) surgical duration < 180 minutes, (b) expected bedrest < 24 hours, (c) postoperative urinary retention < 1000 cc, or (d) any volume of urinary residual. For CIC, inappropriate use was defined as (a) urinary retention < 500 cc in females and < 750 cc in males, or (b) urinary residual < 200 cc. The specified volumes were determined using ultrasound bladder scans that were approved and validated by each hospital. (20) To diagnose a UTI, three criteria had to be met: (a) bacterial count of ≥ 10^5 CFU/ml in the urine sediment, (b) leukocyte count > 5 leukocytes in the urine sediment, and (c) at least one clinical symptom, such as painful or frequent urination, fever exceeding 38.0°C, flank pain, general malaise, or delirium. (21)

To support the implementation and sustainability of the protocol, we enlisted local champions from each department in each hospital. These champions were selected for their leadership roles and played a pivotal part in ensuring adherence to the protocol, addressing practical challenges, and tailoring the program to the needs of their respective hospitals. Local champions collaborated with the research group in developing the educational program and participated in its delivery. The primary researcher held two-monthly meetings with these local champions to monitor compliance and provide feedback.

An educational program, designed for healthcare professionals (specifically nurses), served as the foundation for disseminating the newly established protocol. It included modules on the new protocol, guideline adherence, catheter insertion techniques, and infection prevention, all tailored to the specific needs of postoperative neurosurgical patients. This program was developed by the research group at the start of the study and further adjusted during implementation, with the help of local champions, to accommodate logistical preferences and the specific circumstances of individual hospitals. Tailoring was applied to optimize the program's relevance and effectiveness for the target audience, as research suggests that context-specific strategies are more likely to improve implementation outcomes. (22)

The educational program was disseminated using a combination of real-life and online training sessions, which were conducted by the primary researcher in collaboration with a research team nurse. To ensure thorough understanding and adherence, implementation included initial training sessions for all relevant staff, followed by three-monthly meetings to address challenges and reinforce adherence. The training utilized various tools, including interactive slide decks, instructional videos, and printed materials, which were distributed via email and uploaded to a dedicated online platform accessible to all staff within each hospital. The program was further integrated into daily routines through participation in team meetings and continuous support provided by department-specific newsletters and educational posters placed in team stations. To sustain adherence over time, the program included regular refresher sessions and continuous engagement by local champions who monitored compliance and addressed any emerging issues.

Outcomes

The primary outcomes were the proportions of inappropriate IDUC and CIC. Secondary outcomes included the proportions of total inserted IDUCs and CIC, urinary tract infections and length of hospital stay.

Statistical analysis

Data were analysed with SPSS version v29.0. Descriptive analyses are presented as raw numbers and percentages. Continuous data are presented as means with standard deviations. We analysed the primary outcomes (appropriate/inappropriate IDUC and CIC insertion) on an ordinal scale, counting the number of catheters a patient received during admission to the neurosurgical department, and grouping them as 0 (no catheter), 1 (1 catheter inserted), 2 (2 catheters inserted) and 3 (3 or more catheters inserted). The grouping of catheter use was a pragmatic decision based on the expected distribution of catheter use among patients. To assess differences in the distribution of surgery types between the before and after groups, a Chi-square test was performed. Additionally, all regression analyses were adjusted for age, sex, type of surgery, and hospital to account for potential confounding. Two analyses were performed for the ordinal outcome using ordinal logistic regression: one unadjusted and one adjusted for the aforementioned variables. Similarly, the secondary outcomes, comprising the total number of IDUCs and CICs inserted, were also analysed with ordinal logistic regression, following the same method used for the primary outcomes. These analyses generated common odds ratios (ORs) to describe the likelihood of differences in catheter use categories between the after group and the before group. We opted for ordinal logistic regression instead of simple binary logistic regression to increase statistical power. (23) Statistical significance was determined at the alpha = 0.05 level, with 95% confidence intervals excluding 1 indicating statistical significance. Given that less than 5% of the data was missing, the exclusion of patients with missing values was deemed to have a minimal impact on the analysis. (24) Prior to the study, no formal power calculation was conducted due to the uncertainty regarding the frequency of IDUC insertions and CICs peri- and postoperatively. Additionally, the number of surgeries performed was impacted by the COVID-19 pandemic.

Ethics

Ethical approval was obtained on October 26, 2020, from the Medical Ethics Committee, accompanied by a waiver for patient consent. This provision was granted due to the study's engagement in quality improvement, which posed a negligible risk to patients, coupled with the impracticality of conducting the study without such a waiver. Local feasibility was approved by the local institutional review boards of all participating hospitals. The study protocol has been published previously. (25) The study is registered in the Netherlands Trial Register.

Results

A total of 3439 patients were admitted for either transsphenoidal pituitary gland tumour surgery or spinal fusion surgery and 2922 patients underwent screening (Figure 1). After exclusions, the before group comprised 2167/2711 (80%) patients, while the after group consisted of 544/2711 (20%) patients.

Figure 1: Flow chart of patient selection for the before-and-after study groups. CIC, clean intermittent catheterisation; IDUC, including indwelling urinary catheterisation.

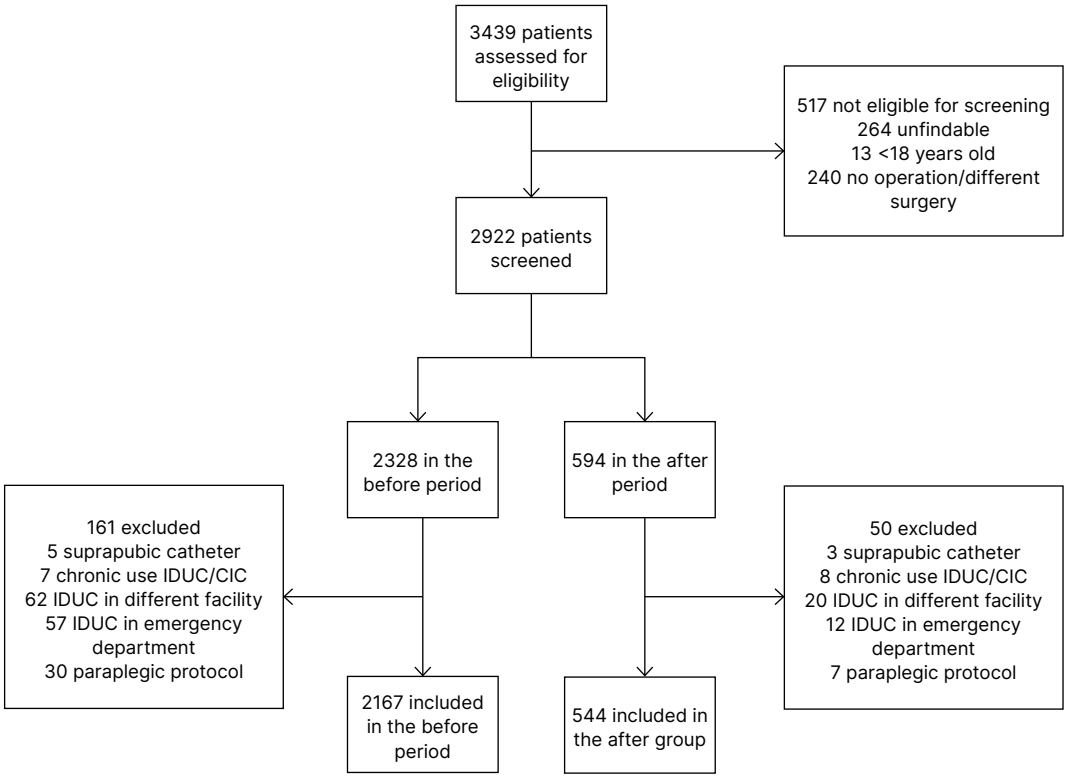


Table 1: Characteristics of neurosurgical patients before and after the implementation

	Before *(n=2167)*	**After** *(n=544)*	**Total** *(n=2711)*	**Missing**
Gender, n (%)				0
Male	991 (45.7)	230 (42.3)	1221 (45.0)	
Age, *mean (SD)*	59.1 (15.1)	60.8 (15.1)	59.4 (15.1)	0
Body Mass Index, *mean (SD)*	27.1 (5.2)	27.2 (5.1)	27.1 (5.2)	27
Duration of surgery in minutes, *mean (SD)*	146.8 (92.0)	149.6 (99.5)	147.4 (93.6)	15
Surgery type, *n (%)*				0
Pituitary	395 (18.2)	105 (19.3)	500 (18.4)	
Spondylodsis	1321 (61.0)	304 (55.9)	1625 (59.9)	
Trauma/tumour debulking	451 (20.8)	135 (24.8)	586 (21.6)	

The characteristics of the study population are presented in Table 1, comparing the before (n=2167) and after (n=544) periods. The gender distribution shifted from 45.7% male and 54.3% female in the before period to 42.3% male and 57.7% female during the after period. The mean duration of surgery was 146.8 minutes in the before period, compared to 149.6 minutes during the after period. Regarding the types of surgery, pituitary surgeries accounted for 18.2% of the patients in the before group and 19.3% in the after group; spondylodesis accounted for 61.0% (before group) and 55.9% (after group); and trauma or tumour debulking comprised 20.8% (before group) and 24.8% (after group). To assess whether the distribution of surgery types differed significantly between the before and after groups, we performed a Chi-square test. The overall distribution did not show a significant difference (χ^2=5.37, p=0.068). However, when analyzed per surgery type, a significant shift was observed in the proportion of spondylodesis (χ^2=4.46, p=0.035) and trauma/tumor debulking surgeries (χ^2=3.88, p=0.049), while the distribution of pituitary surgeries remained unchanged (χ^2=0.27, p=0.61).

The Grotta chart in Figure 2 visually represents the distribution between appropriately and inappropriately IDUC and CIC, highlighting a trend towards more appropriate catheter placements in the after group. The percentage of patients without inappropriate IDUC increased from 45.6% to 56.6%, while those with one inappropriate IDUC decreased from 51.4% to 38.3%. For CIC, the improvement was even more pronounced: the percentage of patients without inappropriate CIC more than doubled, rising from 33.8% to 66.7%, and those with one inappropriate CIC decreased from 53.2% to 23.8%. When examining more instances of catheter use, there was a slight increase in patients with two inappropriate IDUCs, from 2.7% to 4.6%, and two inappropriate CICs, from 6.9% to 7.1%.

Figure 3 shows a reduction in overall catheter use. The percentage of patients without any IDUC increased from 53.7% to 64.0%, and those with one IDUC decreased from 43.5% to 32.2%. However, the proportion of patients with two or more IDUCs slightly increased, from 2.5% to 3.5%. Similarly, for CIC, the percentage of patients not requiring any CIC rose from 89.1% to 92.3%, while those receiving one CIC decreased from 8.1% to 6.2%.

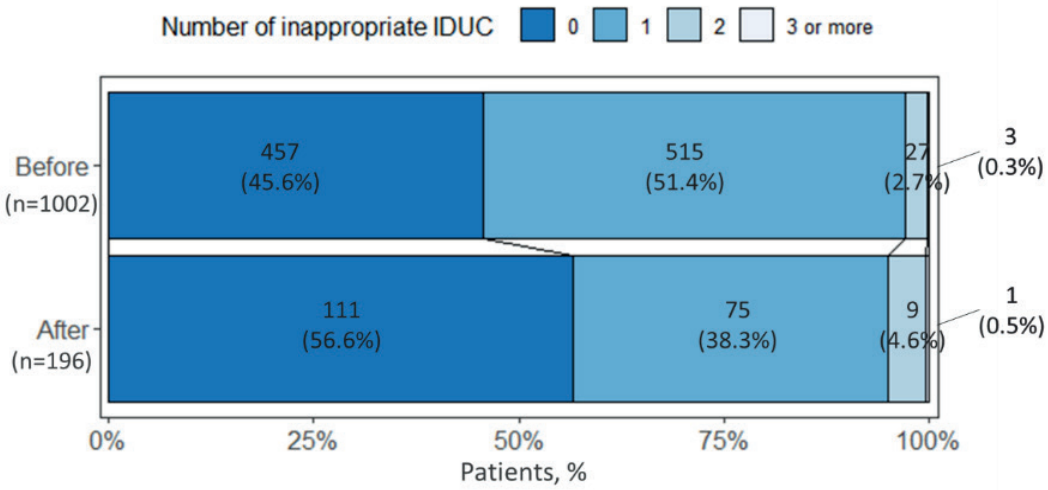
Table 2: Ordinal logistic regression analysis for total and inappropriate indwelling urinary catheterization and clean intermittent catheterization.

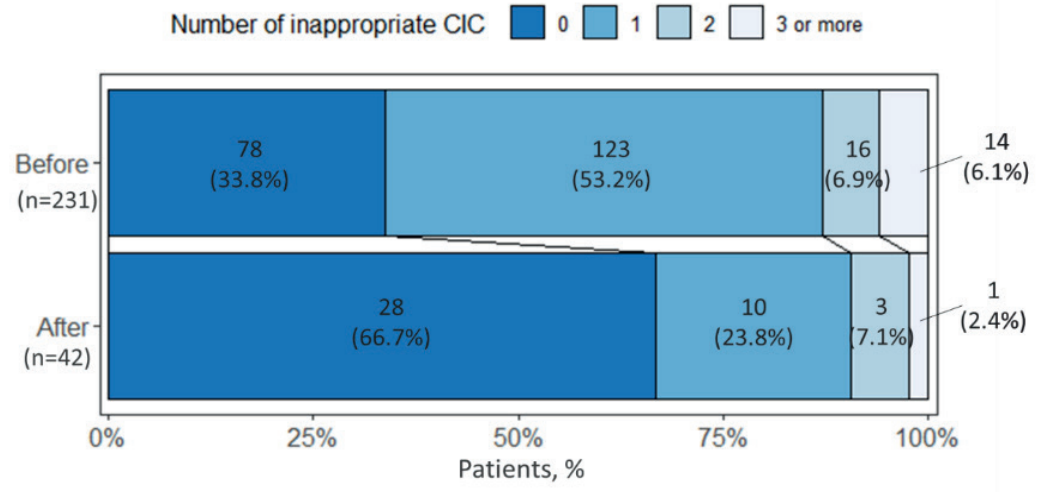
	Before *Mean* (SD)*	**After** *Mean* (SD)*	**Unadjusted common odds ratio** *(95% CI)*	**Adjusted** Common odds ratio** *(95% CI)+*
Number of inappropriate IDUC	0.58 (0.56)	0.49 (0.61)	0.68 (0.48-0.96)	0.72 (0.52-1.05)
Number of inappropriate CIC	0.85 (0.79)	0.45 (0.74)	0.28 (0.14-0.56)	0.25 (0.13-0.51)
Number of total IDUC	0.49 (0.56)	0.40 (0.57)	0.68 (0.55-0.82)	0.61 (0.50-0.76)
Number of total CIC	0.15 (0.50)	0.10 (0.40)	0.68 (0.50-0.92)	0.74 (0.51-1.02)

Legend: * Mean number of catheters per patient, ** Adjusted analyses included age, sex, type of surgery and hospital affiliation,+ 95% confidence intervals excluding 1 indicate statistical significance at alpha = 0.05 level. IDUC: indwelling urinary catheter CIC: clean intermittent catheterization

Figure 2: Distribution of inappropriate indwelling urinary catheterization (IDUC) and clean intermittent catheterization (CIC)

The bar charts illustrate the distribution of inappropriate IDUC (top) and inappropriate CIC (bottom) in the before and after groups. The numbers inside the bars represent the absolute number of patients, while percentages indicate the proportion of patients within each group.





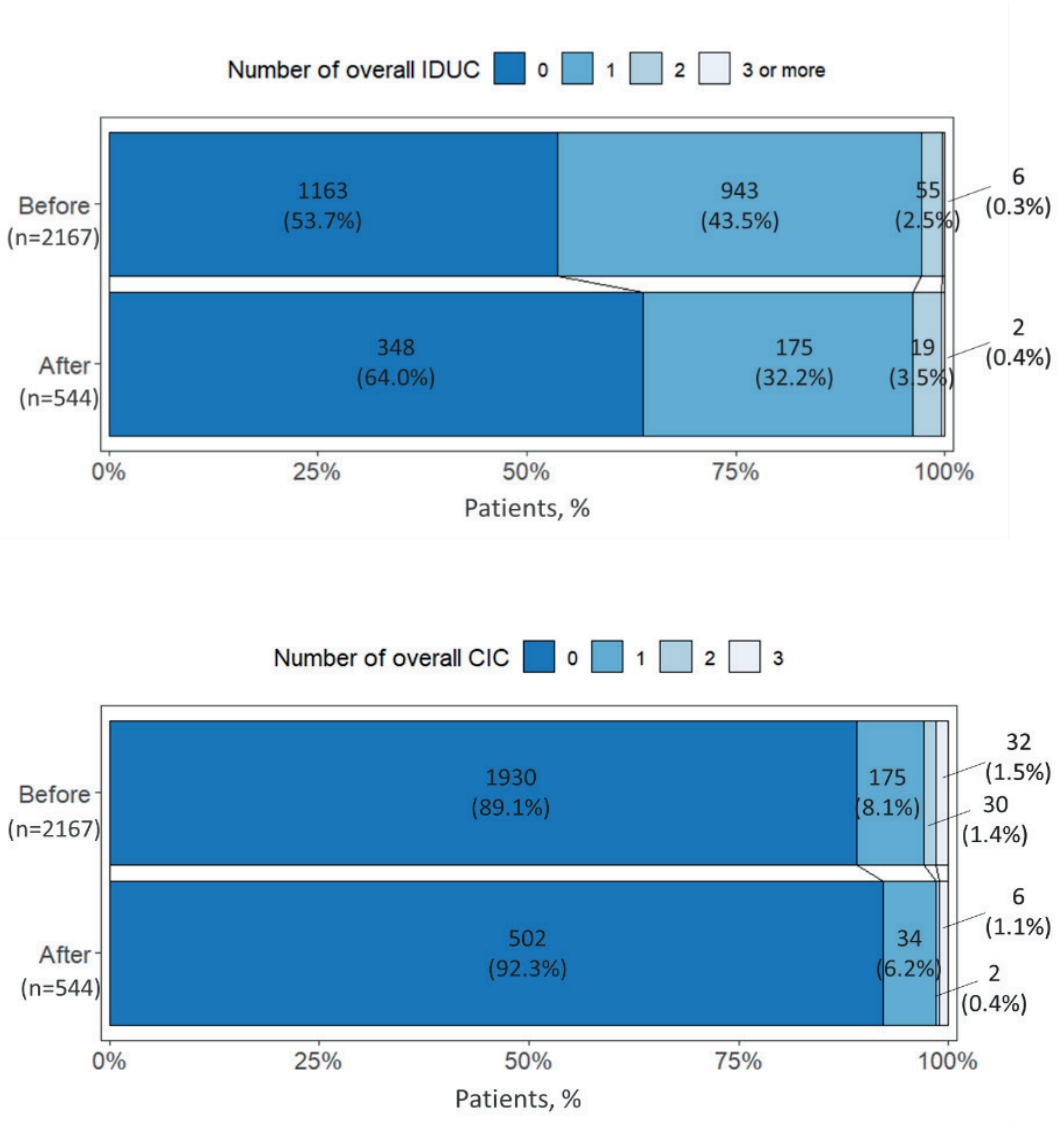
Legend

The colors represent the number of catheterizations a patient received:

- 0 (dark blue):
  No catheterization
- 1 (medium blue):
  One catheterization
- 2 (light blue):
  Two catheterizations
- 3 or more (very light blue): Three or more catheterizations

Figure 3: Distribution of total indwelling urinary catheterization (IDUC) and clean intermittent catheterization (CIC)

The bar charts display the overall distribution of total IDUC (top) and total CIC (bottom) in the before and after groups. The numbers inside the bars indicate the absolute number of patients, and percentages show the proportion of patients within each group.



Legend

The colors represent the number of catheterizations a patient received:

- 0 (dark blue):
  No catheterization
- 1 (medium blue):
  One catheterization
- 2 (light blue):
  Two catheterizations
- 3 or more (very light blue): Three or more catheterizations

Table 2 confirms these trends through ordinal logistic regression. The unadjusted OR of 0.68 (95% CI: 0.48–0.96) indicates that patients in the after group are significantly less likely to receive inappropriate IDUCs compared to the before group, as the 95% confidence interval excludes one. The adjusted OR of 0.72 (95% CI: 0.52–1.05) shows a similar trend but does not reach statistical significance. For inappropriate CIC placement, the unadjusted OR is 0.28 (95% CI: 0.14–0.56), and the adjusted OR is 0.25 (95% CI: 0.13–0.51), both indicating statistically significant reductions. For total catheter use, the unadjusted OR for IDUCs is 0.68 (95% CI: 0.55–0.82), and the adjusted OR is 0.61 (95% CI: 0.50–0.76), both showing statistically significant decreases. For CIC, the unadjusted OR of 0.68 (95% CI: 0.50–0.92) indicates a significant decrease, while the adjusted OR of 0.74 (95% CI: 0.51–1.02) reflects a non-significant trend.

In addition to reductions in inappropriate catheter use, the total number of catheters used is lower in the after group. For IDUC, both the unadjusted OR of 0.68 (95% CI: 0.55–0.82) and the adjusted OR of 0.61 (95% CI: 0.50–0.76) indicate a significant reduction. For CIC, the unadjusted OR of 0.68 (95% CI: 0.50–0.92) indicates a significant decrease, while the adjusted OR of 0.74 (95% CI: 0.51–1.02) suggests a non-significant trend towards reduced total CIC use.

Table 3: Urinary tract infections and length of hospital stay.

	Before *(n= 2167)*	**After** *(n=544)*	**Total** *(n=2711)*
Urinary tract infection, *n (%)*	31 (1.4)	7 (1.3)	38 (1.4)
Male	7 (22.6)	4 (57.1)	11 (29.0)
Female	24 (77.4)	3 (42.9)	27 (71.1)
Length of hospital stay in days, *mean (SD)*	4.9 (6.9)	5.1 (7.6)	4.9 (7.0)

Legend: SD = standard deviation

UTI rates and the average length of hospital stay during the before and after periods are presented in Table 3. In the before period, the UTI rate was 1.4%, which decreased to 1.3% in the after period. The mean hospital stay duration was 4.9 days in the before period and increased slightly to 5.1 days during the after period.

Discussion

In this multicentre study, implementing a standardized protocol significantly reduced the inappropriate and overall use of IDUC and CIC in patients undergoing pituitary gland tumour and spinal fusion surgery. Unadjusted odds were significant across all categories; however, adjusted odds remained significant only for inappropriate CIC and overall IDUC. This finding is consistent with previous research, indicating that targeted strategies can effectively change behaviours and contribute to organizational change. (26, 27)

The shift towards fewer inappropriate IDUCs and CICs reinforces current clinical guidelines and research advocating for minimizing unnecessary urinary catheter use to reduce the risk of catheter-related bloodstream infections and other complications. (9, 12) This reduction is crucial for the quality of care and patient safety and reflects the healthcare sector's broader transition towards less invasive, conservative, and

patient-centred care practices. (28-30) However, our study noted a slight increase in patients with two or more inappropriate IDUCs and CICs, suggesting a subgroup with complex needs not fully addressed by the strategy. This finding highlights the need for further research to refine strategies for such patients. (31) The impact on total CIC was less pronounced, yet there was still a modest and promising improvement, as evidenced by the increase in the percentage of patients not requiring CIC. This finding aligns with the literature that suggests a floor effect in certain patient populations, where further reductions are limited by clinical necessity. (32)

The reduction in inappropriate catheter use underscores the importance of strategies that prevent direct harm to patients, including physical injuries and psychological distress caused by unnecessary interventions. (33) The educational program and local champions were critical in improving adherence to the revised protocol. However, several factors might have influenced the extent of the reduction. Clinician adherence to new protocols may vary, influenced by individual preferences, experiences, and perceptions of guideline efficacy. (34) Integrating catheterization responsibilities, traditionally under the purview of physicians, into the nursing domain could enhance protocol adherence. (35) Complex patient conditions impact catheterization needs, possibly explaining the limited reduction in perceived inappropriate use. (36) The necessity to conduct part of the training online due to COVID-19 might have led to suboptimal adherence to the new protocol. Online training, while accessible and scalable, often lacks the interactive components and immediate feedback inherent to in-person training, which are critical for ensuring comprehensive understanding and practical application of new guidelines. (37) Existing practices and institutional culture at various hospitals can affect the implementation of new strategies, with longstanding practices posing challenges to adopting new guidelines. (38)

The stable duration of hospital stays in our study is promising, echoing findings from previous research. Studies have reported that strategies aimed at reducing catheter usage do not prolong hospitalization and are associated with a decrease in catheter associated UTIs. (39, 40) This reinforces the potential of such measures to enhance patient outcomes without compromising the quality of care. (41) A possible explanation for the unchanged hospital stay in our study, despite the reduction in both total and inappropriate IDUC and CIC use, lies in differences between the before and after groups. The after group included a higher proportion of trauma/tumor debulking surgeries, a slightly older patient population, and longer surgical durations, all of which can impact recovery time. These findings suggest that while optimizing catheterization reduces unnecessary interventions, hospital stay is influenced by multiple factors beyond catheter use. Additionally, a Chi-square test revealed a significant difference in the distribution of surgery types between the before and after groups, specifically for spondylodesis and trauma/tumor debulking surgeries. However, given that our adjusted analyses accounted for surgery type, alongside age, sex, and hospital affiliation, the observed reductions in catheter use are unlikely to be solely driven by shifts in surgical case distribution.

Strengths and limitations

Our study has several strengths. First, our study's multicentre approach, involving four hospitals, enhances the generalizability of our findings. The inclusion of university, teaching, and general hospitals suggests that our results may be applicable across a broad spectrum of clinical environments and patient populations. Second, the detailed data collection by a team of researchers, nurses, and assistants ensures the accuracy

and consistency of our patient data. Third, standardized protocols contributed to the reliability of the data.

Several limitations should be acknowledged. First, the shorter post-intervention period, primarily due to the COVID-19 pandemic, may have limited the full impact of the intervention. This was further compounded by the prolonged uncertainty regarding whether the study could proceed, as well as the cancellation of surgeries during the pandemic, which disrupted normal clinical workflows and potentially delayed the implementation of the new protocol. Second, the challenge of varying pre-existing catheterization protocols across participating hospitals also posed a significant obstacle to uniform adherence. In particular, hospitals with pre-study protocols that diverged more remarkably from the study protocol—especially regarding thresholds for urinary retention volumes or residual urine levels and the criteria for catheterization—required greater adaptability from nursing staff compared to hospitals whose existing protocols were already more closely aligned. While we have adjusted in our analysis to accommodate these differences, the diversity of pre-study practices may have influenced adherence to the newly implemented protocol. Third, although the implementation plan was conducted as intended, certain limitations may have influenced its feasibility. Variations in hospital logistics and the ongoing impact of the COVID-19 pandemic posed challenges to reaching all staff. Staff shift patterns made it difficult to ensure complete attendance at training sessions. To address this, we focused on repeated sessions and localized adaptations to maximize participation. Nevertheless, it is possible that not all staff members, including newly hired and existing staff, were able to fully complete the educational program during the study period.

Future research
Future efforts should focus on developing a clear, measurable action plan to sustain the outcomes observed in this study. This plan could include strategies such as ongoing training, regular audits, and structured feedback loops to reinforce adherence to the protocol over time. Additionally, future research should evaluate the long-term sustainability of these strategies, particularly under varying hospital conditions and external challenges such as pandemics. Expanding this intervention to other surgical specialties could enhance patient care across various clinical contexts, and its principles may be applicable to other areas of healthcare, such as intravenous line placements or interdisciplinary task distribution. To conclude, future studies should also systematically evaluate staff engagement and experiences during the implementation phase.

Conclusion

This multicentre study demonstrates that implementing a uniform urinary catheter protocol in multiple hospitals through an educational programme leads to improved postoperative quality of care in neurosurgical patients after pituitary gland tumour or spinal fusion surgery. By significantly reducing total IDUC and inappropriate CIC, this study aligns with the trend toward patient-centred, less invasive healthcare practices. It underscores the importance of ongoing education, strict adherence to standardized protocols, and the integration of practices in both medical and nursing fields.

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Chapter 7
Patient participation in urine specific gravity screening for arginine vasopressin deficiency in an inpatient neurosurgical clinic

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Summary

Objective
Detecting hypotonic urine (specific gravity < 1005 g/l) is crucial for the early identification of arginine vasopressin deficiency (AVP-deficiency), a common complication after pituitary surgery. This study aimed to evaluate the agreement between urine specific gravity measurements taken by patients using urine test strips and those taken by nurses using a refractometer, to assess the reliability of patient-conducted measurements for diagnosing this condition.

Design
A prospective cohort study was conducted in a neurosurgical ward.

Patients
The study included 110 participants who collectively provided 609 specific gravity measurements.

Measurements
Specific gravity measurements were taken using Combur-10® urine test strips by patients and using an ATAGO MASTER-SUR/Nα refractometer by nurses. Agreement was analyzed using Weighted Kappa and Intraclass Correlation Coefficient (ICC).

Results
Moderate agreement was found between patient-conducted measurements and those from the refractometer (Kappa = 0.47, ICC = 0.69). Substantial to good agreement was observed between patient and nurse measurements using urine test strips (Kappa = 0.82, ICC = 0.89). A threshold of 1.015 g/l in test strip measurements ensured no cases of hypotonic urine were missed, reducing the need for nurse-led testing by 50%. Patient satisfaction was high (mean 7.8), while nurse satisfaction was lower (mean 6.4).

Conclusions
Although patients are less accurate than nurses in measuring specific gravity, they can reliably screen for hypotonic urine in AVP-deficiency diagnostics using urine test strips. A higher cut-off point improves diagnostic accuracy, enhances patient participation, and reduces the screening workload for nurses.

Introduction

Globally, the incidence of pituitary gland and (para)sellar tumours ranges from 1.29 to 3.49 per 100,000 people each year (1, 2). While endoscopic transsphenoidal surgery is the intervention of choice for most functioning pituitary adenomas and larger non-secreting tumors causing mass effect, smaller non-secreting microadenomas and prolactin-secreting adenomas are often managed with a watchful waiting approach or treated with medical therapy, such as dopamine-agonists (3). In the early postoperative phase, there is a high incidence of fluid balance disorders, characterized by polyuria in the first 24 hours postoperatively and later development of hyponatraemia due to transient altered regulation of arginine vasopressin (AVP) or other causes. (4, 5). The incidence of AVP deficiency (AVP-D) in the early postoperative phase varies widely, ranging from 2% to 54%, as also reported in a recent systematic review, which highlights the impact of differing diagnostic criteria and follow-up durations on reported rate (6, 7).

AVP-D manifests through symptoms including intense thirst (polydipsia), excessive urination (polyuria), and potential dehydration and electrolyte imbalances in case of impaired intake or thirst feeling (8, 9). Clinicians diagnose AVP-D using varying criteria, often based on polyuria thresholds (e.g., >300 mL/hr or >40-50 mL/kg/24 hr) and hypotonic urine with a specific gravity <1.005 g/L. Diagnostic approaches may also include sodium and osmolality measurements, though thresholds can differ between studies (5, 7, 10). In our hospital, we adhere to the criteria established by de Vries et al. (2021), which define hypotonic polyuria as diuresis >300 mL/h for three consecutive hours, urine specific gravity <1.005, and the presence of at least one of the following: serum sodium >145 mmol/L or serum osmolality >300 mOsm/kg (6).

Due to the abrupt nature of AVP-D, prompt detection is critical for mitigating the risks associated with potential electrolyte disturbances. Currently, nurses play a crucial role in managing postoperative fluid-related aspects in patients (11). Standard care involves monitoring patients' fluid intake, urinary output, and SG every 6 hours. The SG is measured until discharge from the hospital, while the fluid balance is monitored at home for 14 days after discharge (6). In this process, the ATAGO MASTER-SUR/Nα handheld refractometer is used to measure SG. Although refractometers are precise, their use can be complex and potentially challenging due to issues such as light interference affecting the readability of results (12). Studies have suggested that urine test strips could be an effective alternative for determining SG (13). Such easy to use urine test strips offer an additional promising opportunity for enhancing patient participation and alleviating the burden of tasks of nurses in the postoperative care process during hospital admission (14).

In the present-day healthcare landscape, patient participation has taken a prominent place. Active engagement of patients in their own care processes has been shown to improve the overall quality of care and enhance patients' understanding of their conditions (15). This approach has yielded positive outcomes in various medical fields, such as enhancing therapy adherence and improving health outcomes in cardiac patients (16, 17). For patients recovering from pituitary surgery, actively participating in monitoring their SG and thereby recognizing early signs of the potential onset of AVP-D may be beneficial. This involvement may enhance their understanding of the clinical relevance and, once diagnosed, management of AVP-D (18).

To date, no study has explored the feasibility and accuracy of patient participation using urine test strips for SG measurement post-pituitary gland tumour surgery in a hospital setting. We aimed to investigate the agreement between SG measurements taken by patients using urine test strips and those performed by nurses with a refractometer.

Materials and Methods

Design and setting

This study was conducted as a prospective cohort study on the neurosurgical ward of an academic hospital in the Netherlands. It aimed to evaluate the level of agreement between SG measurements obtained using urine test strips by patients and those obtained by nurses using the ATAGO MASTER-SUR/Nα refractometer. Additionally, we assessed both patient and nurse satisfaction. Data collection occurred between February 2022 to January 2024.

Participants
Participants were recruited by the primary researcher upon their admission to the neurosurgical ward, prior to undergoing pituitary gland tumour surgery. Eligibility criteria required individuals to be 18 years of age or older. Excluded were patients with insufficient proficiency in Dutch or English, cognitive impairments, postoperative neurological deficits, significant visual limitations (defined by an inability to read the numbers on the test strip), colour blindness, mobility limitations, dependence on chronic catheter use, or urostomy.

Intervention and procedures
Two tools for measuring urine SG were used: the Combur-10® urine test strips (Roche Diagnostics, Basel, Switzerland) and the ATAGO MASTER-SUR/Nα refractometer. The Combur-10 measures various urine components, including SG in intervals of five points, ranging from 1.000 to 1.030 g/l. Due to the fixed five-point intervals of the Combur-10 test strips, a reading within a range (e.g., 1011-1015 g/l) cannot determine an exact SG value. The refractometer measures SG in one-point intervals from 1.000 to 1.060 g/l. Each patient provided six urine samples between 08:00 and 20:00 starting the day after surgery. For each sample, SG measurements were taken by the patient using a test strip, a nurse using a test strip and the refractometer. Patients and nurses conducted their readings independently. Test strip results were read after one minute according to the manufacturer's instructions, while the refractometer was used according to hospital guidelines. The refractometer was calibrated at the start of the study. All ward nurses (n=60) received training in using both tools, with refresher sessions every six months. This training was managed by the study group, which included the primary researcher and five nurses who also selected participants and trained patients. An infographic was created to enhance patient understanding and compliance. Study progress was communicated through the department newsletter.

Data collection
Patients reported outcomes of the urine test strip on a designated form, while nurses entered results into the electronic patient file. Data collected included gender, age, education level, SG, urinary catheterization, bedrest periods, patient-reported thirst, serum osmolarity, sodium levels, fluid balance, and desmopressin administration.
The primary researcher and study group routinely cross-checked data, and a second researcher reviewed it independently twice. To understand how satisfied patients are with self-measuring SG a short questionnaire was developed. Patients rated three questions on a scale from 1 (completely disagree) to 10 (completely agree): their ability to measure SG using a urine test strip, how well they could read the SG value, and their overall opinion on self-measuring SG. Nurses rated their perspective on patients' ability to measure SG and their overall opinion on it.

Outcomes
The primary outcome was the agreement between SG measurements by patients using Combur-10® urine test strips and the ATAGO MASTER-SUR/Nα refractometer. Secondary outcomes included the agreement between SG measurements by patients and nurses using urine test strips, as well as between nurses' test strip measurements and the refractometer. Additionally, patient and nurse satisfaction was assessed.

Sample size
We aimed to include 100 patients, each providing six urine samples, for a total of 600

samples. This sample size was chosen to reflect typical clinical scale and ensure robust statistical power. Although no formal power calculation was done, the sample size is expected to provide sufficient power to detect substantial agreement with an Intra Correlation Coefficient (ICC) of 0.7, assuming a 95% confidence level and 80% power.

Statistics

Analyses were performed using SPSS version 29.0. Descriptive statistics for categorical variables are reported as raw numbers and percentages, while continuous variables are presented as means with standard deviations. Normality of continuous data was assessed using the Kolmogorov-Smirnov test due to the sample size (n=600). For categorical variables, no normality testing was performed, as they are presented using frequency distributions. The primary outcome was assessed using Kappa statistics and the ICC. Weighted Kappa accounts for the ordinal nature of the data by assigning varying weights to disagreements (19). To apply this method, continuous refractometer SG measurements were categorized to match the ordinal scale of the urine test strips. The following categorizations were performed in which the highest values were merged with lower values to create uniform scales: 1. patient strip vs. refractometer: converted the nine-category refractometer scale to six categories, 2. patient strip vs. nurse strip: reduced to a uniform six-category scale, and, 3. nurse strip vs. refractometer: aligned the nurse's seven-category scale to the refractometer's nine-category scale, standardizing it to seven points. The interpretation of Kappa values and ICC values is summarized in Table 1 for clarity and ease of comparison (20, 21). ICC analysis assumed continuous SG measurements, using a two-way mixed-effects model with patients' and nurses' measurements as random effects and measurement method as a fixed effect. This model was selected to account for inter-individual variability and measurement consistency across different instruments (22). Despite the non-normality of the SG measurement data, which persisted even after logarithmic and square root transformations, we proceeded with the ICC analysis given its robustness to deviations from normality (23). Sub-analyses were conducted based on gender, age, educational level (secondary education, vocational education, higher professional education, university), and individual measurements. Less than 5% of the data was missing, and cases with missing values were excluded, which had minimal impact on the overall analysis (24).

Table 1: Interpretation of Kappa and ICC Values

Statistic	Range	Interpretation
Kappa	0.00	Chance agreement
	0.10 – 0.20	Slight agreement
	0.21 – 0.40	Fair agreement
	0.41 – 0.60	Moderate agreement
	0.61 – 0.80	Substantial agreement
	0.81 – 0.99	Near-perfect agreement
	1.00	Perfect agreement
ICC	Below 0.50	Poor reliability
	0.50 – 0.75	Moderate reliability
	0.75 – 0.90	Good reliability
	Above 0.90	Excellent reliability

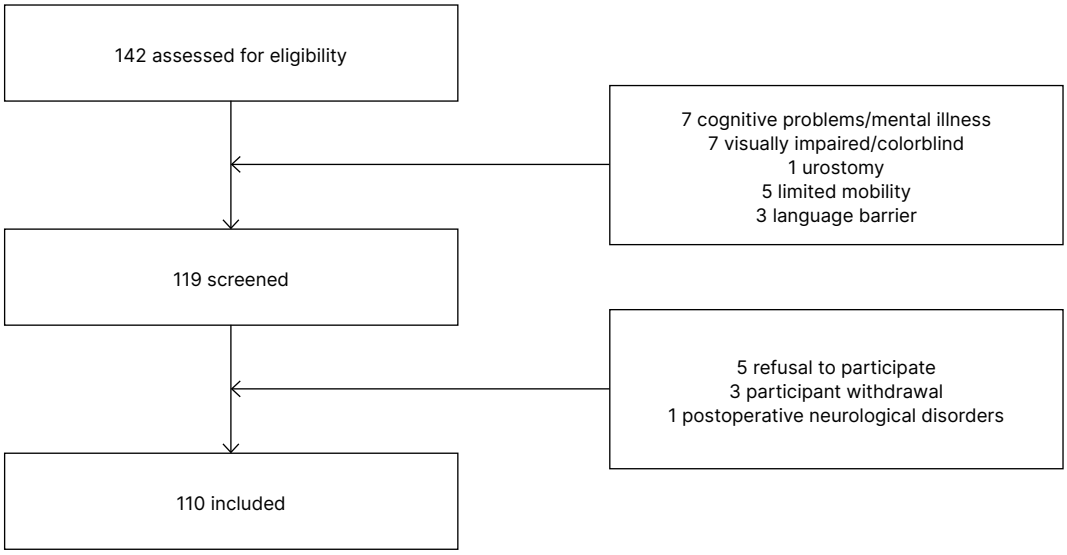
Ethics

Ethical approval for this study was evaluated by the Medical Ethics Committee of the Leiden University Medical Centre (METC LDD). The committee determined that the study (METC number N21.123), does not fall under the scope of the Medical Device Regulation or the Medical Research Involving Human Subjects Act (WMO) in the Netherlands. Specifically, the METC concluded that this study is not classified as a clinical trial, as it does not involve scientific research requiring participants to be subjected to invasive medical interventions, as defined by Article 1, paragraph 1, sub b of the WMO. As such, the study was exempt from full ethical review. Nevertheless, the study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki (23). Informed consent was obtained from all participants prior to their inclusion in the study.

Results

A total of 142 individuals were assessed for eligibility and the final sample comprised 110 individuals (Figure 1).

Figure 1: Flowchart of patient selection



The characteristic of the study population are presented in table 2. Of the 110 patients, 71 (64.5%) had a macroadenoma and 39 (35.5%) had a microadenoma. The majority had hormone-secreting tumors (prolactinoma: 31, acromegaly: 25, Cushing's disease: 15, TSH-secreting adenoma: 1), while 25 had non-functioning adenomas, 12 had cystic lesions (Rathke's cleft cyst, epidermoid cyst, or other cysts), and 1 patient had a craniopharyngioma. All patients had an intact thirst sensation.

Table 2: Characteristics of study population

	N = 110
Sex, n (%)	
Female	74 (67.3)
Male	36 (32.7)
Age, years, mean (SD)	48.2 (16.3)
Length of hospital stay, days, mean (SD)	3.5 (1.2)
Indwelling urinary catheter, n (%)	14.0 (12.7)
Bedrest, n (%)	15.0 (13.6)
Hours bedrest, mean (SD)	24.0 (0)

The SG measurement counts varied depending on the method used. The total number of measurements for patient test strips (n= 617), for nurse test strips (n=609), and refractometer (n=611). In total, nurses missed recording 8 measurements test strip and the refractometer 6 measurements compared to patient records. The dataset includes 609 sets of measurements where all three methods were used. 11 out of 110 (10%) patients received desmopressin treatment based on clinical judgment for suspected AVP deficiency.

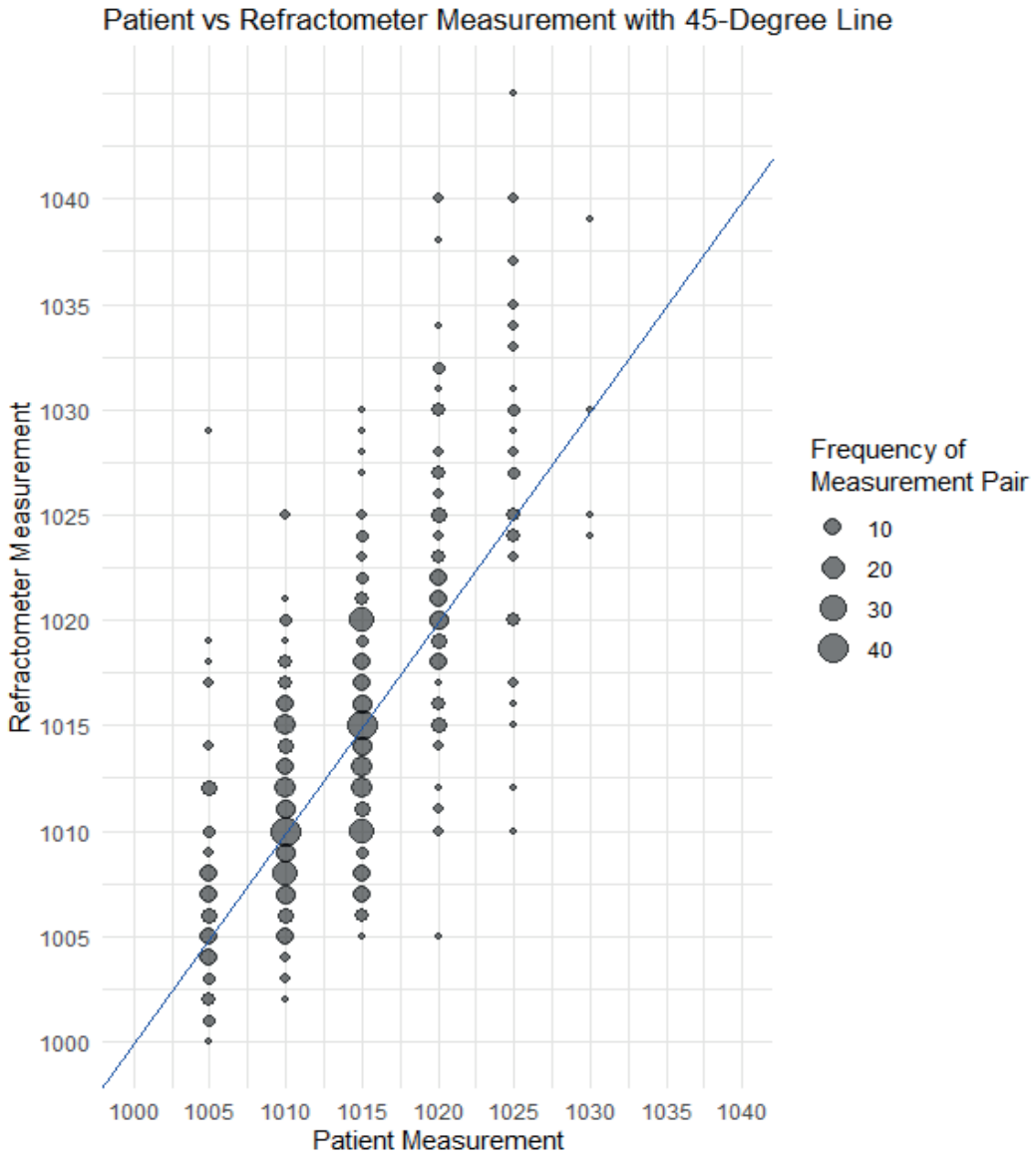
The scatter plot (Figure 2) and corresponding table (Table 3) compare SG measurements between patient test strip and the refractometer, revealing a concentration of measurements between SG values of 1.005 g/l and 1.020 g/l. SG measurements below 1.005 g/l were rare. Setting a threshold of 1.015 g/l for test strip measurements ensures that none of the corresponding refractometer or other test strip measurements fall below 1.005 g/l, thereby indicating that no cases of hypotonic urine (SG < 1.005 g/l) are missed. These measurements encompass 350/611 (57.5%) of the total.

Table 3: Crosstabulation of patient test strip measurement and refractometer SG measurements (g/l), categorized by the cut-off points from the urine test strip

Specific gravity patients ↓ /refractometer →	**1000 - 1005**	**1006 - 1010**	**1011 - 1015**	**1016 - 1020**	**1021 - 1025**	**1026 - 1030**	**1031 - 1035**	**Total**
1000 - 1005	30	30	9	4	0	1	0	74
1006 - 1010	13	91	59	21	3	0	0	187
1011 - 1015	0	47	88	53	14	4	0	206
1016 - 1020	0	3	12	33	29	12	8	97
1021 - 1025	0	1	2	8	11	9	12	43
1026 - 1030	0	0	0	0	2	1	1	4
Total	43	172	170	119	59	27	21	611

Legend: SG = specific gravity.

Figure 2: Scatterplot of patient test strip measurement vs refractometer SG measurements obtained by nurses with frequency of measurement pairs and line of agreement



The results of the Weighted Kappa and ICC analysis are presented in Table 4. Patient test strip vs. refractometry showed moderate agreement with a Kappa of 0.47 (95% CI: 0.42-0.51) and an ICC of 0.69 (95% CI: 0.64-0.73). Nurse test strip vs. patient test strip measurements showed substantial to good agreement with a Kappa of 0.82 (95% CI: 0.79-0.85) and an ICC of 0.89 (95% CI: 0.88-0.91). Nurse test strip vs. nurse refractometer measurements indicated moderate to good agreement with a Kappa of 0.55 (95% CI: 0.51-0.58) and an ICC of 0.77 (95% CI: 0.74-0.81). Sub-analyses by gender, age, educational level, and individual measurements revealed no significant differences. In addition, no significant differences were observed in the agreement between refractometer and urine test strip measurements of SG when comparing patients who received desmopressin with those who did not. As desmopressin administration was based on clinical judgment rather than confirmed AVP deficiency, and not all patients receiving desmopressin presented with low SG values (<1.005 g/L), this subgroup analysis was not presented in full detail. Clinically, when patients exhibited signs suggestive of post-operative AVP-D, such as low SG and high urine volume, this typically transient phase was pragmatically managed with a single dose of desmopressin rather than additional diagnostic analysis with plasma sodium and/or osmolality.

Table 4: Agreement Measures Between SG Measurement Methods

	Weighted Kappa	CI 95%	ICC	CI 95%
Patient strip vs. refractometry	0.466	0.424 - 0.509	0.688	0.641 - 0.729
Patient strip vs. Nurse strip	0.822	0.791 - 0.852	0.893	0.876 - 0.908
Nurse strip vs. refractometry	0.546	0.508 - 0.583	0.774	0.738 - 0.805

Legend
CI: Confidence Interval
ICC: Intraclass Correlation Coefficient

Patient and nurse satisfaction

The survey was completed by 93 out of 110 patients (84.5%). The mean score for measuring SG with a urine test strip was 7.9 (SD 1.6), the mean score for reading the SG value was 8.3 (SD 1.4), and the mean overall opinion on self-measuring was 7.8 (SD 1.4). Of the 60 nurses, 39 (65.0%) responded. They rated patients' ability to measure SG at 6.3 (SD 2.0) and their overall opinion on self-measuring at 6.4 (SD 1.8).

Discussion

Our study aimed to evaluate the agreement between SG measurements obtained by patients using Combur-10® urine test strips and those obtained by nurses using the ATAGO MASTER-SUR/Nα refractometer, as well as patient and nurse satisfaction with this approach. We found moderate agreement between patient test strip measurements and refractometry, suggesting some variability, but also supporting the potential for patient participation after pituitary gland tumour surgery. In contrast, the agreement between nurse test strip measurements and refractometer was higher. The strongest agreement was observed between patient test strip measurements and nurse strip measurements, confirming the reliability of patient measurements when compared to nurse measurements.

An SG value of less than 1.005 g/l is critical in the diagnostic process for AVP-D and

is measured in each urine sample postoperatively until discharge from the hospital (6). Our results showed that when patient test strip measurements were 1.015 g/l, the corresponding refractometer measurements were never below 1.005 g/l. Given this critical threshold for diagnosing AVP-D, this finding suggests that urine test strips can be safely used by patients for SG values of 1.015 g/l and higher. These measurements encompass 57.5% of the total, meaning that for over half of cases, re-measurement by a nurse is unnecessary. However, for the remaining 42.5% of measurements that fall below 1.015 g/l, we recommend verification by a nurse using a refractometer to ensure accuracy and correct diagnosis. This approach is supported by literature emphasizing the importance of collaborative efforts between patients and healthcare providers (25). Such teamwork can ensure accurate monitoring and timely intervention (26). In addition, utilizing this approach can significantly reduce the workload for nurses and minimize the need for additional materials (27).

During the study, 10% of patients (11 out of 110) received desmopressin treatment based on clinical judgment for suspected AVP-D. However, none of these patients met the full diagnostic criteria for AVP deficiency (AVP-D) as applied in our hospital, which are based on the criteria defined by de Vries et al (6). Our results showed no significant differences in the agreement between refractometer and urine test strip measurements of SG between patients who received desmopressin and those who did not. This suggests that desmopressin administration did not appear to influence the accuracy of SG measurements in this study. However, as desmopressin administration was based on clinical judgment rather than a confirmed diagnosis of AVP-D, this finding should be interpreted cautiously.

We observed a discrepancy between the test strip measurements and the refractometer readings, regardless of whether they were taken by patients or nurses. Several factors could have contributed. First, the interpretation of urine test strips can be challenging due to the colour differentiation required on a 5-point scale, which might be subtle and subject to variation in perception (28). Second, refractometers measure the refractive index of urine, which can be affected by the presence of substances such as proteins or glucose, leading to discrepancies compared to the urine test strips that use a colorimetric method (29). Third, patients may have less experience and practice with using urine test strips, potentially leading to less consistent results compared to nurses (30). However, we found no differences in the outcomes of earlier measurements compared to later measurements (e.g., measurement 1 vs. measurement 6), indicating that there was no learning effect, and patient performance remained consistent throughout the study.

The results demonstrated a good agreement between patient and nurse test strip measurements of SG, indicating that patients are capable to perform the test accurately. This aligns with previous literature demonstrating that patients can be effectively trained to use self-diagnostic tools in various settings (31, 32). This suggests that our patient cohort are similarly trainable, enhancing the generalizability of our findings to other patient groups.

Patient satisfaction scores indicated a generally positive reception towards self-measuring SG, with patients feeling confident in their ability to perform and interpret the measurements. Conversely, nurse satisfaction scores were somewhat lower. The difference in satisfaction scores is consistent with findings in the literature, where patients often report higher satisfaction with self-monitoring practices compared to healthcare providers, who may have concerns about accuracy and reliability (33). Ensuring proper training and continuous support to patients can help bridge this gap (34).

This study has several strengths. First, the study was conducted in a real-world clinical setting, enhancing the applicability of the findings. Second, the study design included independent SG measurements by patients as well as nurses, reducing the risk of measurement bias. Furthermore, the study achieved a high level of participation in the satisfaction survey. Limitations in our study included the fact that multiple measurements per patient were conducted, and the dependency between these measurements was not fully accounted for. This may have led to a slight underestimation of the variance. Similar to our study, Genders et al. discussed that in diagnostic accuracy studies, ignoring this correlation can be acceptable as it may not significantly impact the clinical decisions, although it may result in narrower confidence intervals (35). Furthermore, the study did not account for potential differences in SG measurements that could arise from variations in urine concentration at different times of the day or due to different dietary and hydration statuses of the patients. Additionally, the Combur-10 test strips used in this study measure specific gravity in fixed five-point increments (e.g., 1011-1015 g/l), which limits the precision of the reported values. To conclude, our inclusion criteria excluded patients with significant visual limitations, defined as the inability to read the numbers on the test strip, as well as patients with cognitive impairments or postoperative neurological deficits. Patients with pre-existing color blindness were also excluded; however, we did not reassess patients postoperatively who may have experienced improved color vision due to the resolution of chiasmal compression. While necessary to ensure the reliability of patient self-measurements, this may have led to an overestimation of the reduction in nursing workload observed in our study. Patients with visual or cognitive limitations may require additional nurse involvement in the screening process, which could affect the extent of workload reduction when applying this method to a broader patient population.

Currently, SG measurements are discontinued upon patient discharge from the hospital, while fluid balance monitoring continues at home. Extending the use of SG test strips to the home environment could be beneficial, as fluid balance disorders like chronic AVP-D often persist post-discharge. Potentially, SG test strips may also be used for early detection of postoperative SIADH (syndrome of inappropriate antidiuretic hormone secretion) while at home. Future research should therefore explore the integration of digital health technologies with home SG monitoring. Using smartphone applications or connected devices for real-time data to share with healthcare providers in real time could facilitate remote monitoring and timely medical advice, improving the management of postoperative AVP-D and other fluid balance disorders.

Conclusion

This study confirms that patients can effectively measure SG using urine test strips, with a moderate agreement to refractometer readings. The reliability of patient-conducted measurements is further supported by a strong agreement with nurse test strip measurements. Using a relatively high cut-off point of 1.015 g/l, no cases of hypotonic urine were missed, indicating that patient measurements are sufficient for SG values of 1.015 g/l and higher, without requiring re-measurement by nurses. For SG values below 1.015 g/l, verification by nurses using a refractometer is recommended to ensure diagnostic accuracy. High patient satisfaction with self-monitoring supports the potential for integrating patient-led SG measurements into postoperative care, thereby reducing the workload for nurses and enhancing patient participation and satisfaction.

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Chapter 8
General Discussion

This dissertation builds upon the historical importance of urine monitoring, a cornerstone of medical practice for millennia, and underscores the critical role of urinary catheterization in this process. The management of urinary catheters in patients undergoing neurosurgery, particularly transsphenoidal pituitary surgery, is complex and multifaceted (1). The challenges associated with urinary catheter use have been well-documented in the literature, which consistently emphasizes the need for a balanced approach that considers both clinical guidelines, complications and the unique needs of individual patients (2). This dissertation aims to transform critical gaps in postoperative neurosurgical care by proposing a nurse-led, patient-centered approach to urine monitoring and urinary catheter management, particularly after transsphenoidal pituitary and spondylodesis surgery. The goal is to enhance clinical practices, reduce complications, improve the patient experience, and empower both nurses and patients in the decision-making process.

Fluid management and decision-making dynamics

For patients undergoing transsphenoidal pituitary surgery, precise fluid balance management is essential due to the risk of developing AVP-D in the immediate postoperative phase (3, 4). Managing this risk effectively requires more than routine catheterization practices; it calls for a nuanced approach to the timing and removal of IDUCs. **Chapter 2** delves into the complex decision-making surrounding the timing of IDUC removal, a process influenced by multiple factors such as the need to prevent UTIs, maintain fluid balance, and manage nursing workload. This chapter focusses on both physicians and nurses as historically, catheter management has been the domain of physicians, with nurses in supporting roles. However, this chapter challenges the status quo, highlighting that nurse-led management can yield significant benefits by showing that nurses are uniquely positioned to lead in decisions on catheter removal due to their ongoing patient contact and monitoring responsibilities. Shifting catheter management from physician-driven to nurse-driven not only aligns with broader healthcare trends toward more efficient and patient-centered care but also supports literature showing that nurse-led protocols improve patient outcomes across healthcare settings (5).
Studies indicate that nurse-driven protocols are especially effective in high-risk environments, where the continuous patient interaction that nurses provide enhances decision-making quality (6)(6). By empowering nurses to lead in catheter management, these protocols encourage more flexible, responsive care that adapts to patient-specific needs, striking a balance between clinical guidelines and real-time adjustments (7).

Psychological and physical impact of urinary catheterization

Patient-centered care has become a cornerstone of quality healthcare, yet patients are often left out of key decisions, including urinary catheter use after transsphenoidal pituitary surgery, which we demonstrated in chapter 2. This exclusion can lead to discomfort and decreased satisfaction with care (8). To address the experiences from patients, **Chapter 3** delves into their perspectives, highlighting the psychological and physical challenges that catheterization poses. Many patients report discomfort, anxiety, a perceived lack of control and little knowledge of the rationale for IDUC placement, suggesting a need for greater involvement in decisions that impact their care experience (9). This aligns with existing literature indicating that there is often a lack of patient knowledge regarding the indication for urinary catheterization, and that patients generally do not express whether the urinary catheter can be removed (10). Therefore, we propose that patients should be more actively involved in the decision making process to work towards more collaborative care that enhances both physical and psychological

well-being. This proposal is supported by research that supports the idea that patients who are actively involved in their care decisions experience lower anxiety levels and greater satisfaction, contributing positively to their recovery process (11, 12). By informing patients about the risks and benefits of catheter use and involving them in decisions regarding removal, healthcare teams can help patients feel more in control, enhancing their immediate comfort and supporting long-term recovery (8).

Preventing complications through early removal

One of the most critical aspects of urinary catheter management is the timing of removal, as extended catheter use correlates with higher risks of infection and other complications (2). However, this decision must be carefully balanced against potential risks such as urinary retention and residue, particularly in hospitalized patients who require ongoing urine monitoring (13). Despite evidence supporting early removal, there has been limited research from a nursing perspective on the specific timing of postoperative catheter removal and its consequences. **Chapter 4** provides a systematic review of early catheter removal, demonstrating that this practice leads to reductions in CAUTIs, shorter hospital stays, and enhanced patient mobility. These findings advocate for early removal as a preventive care strategy, particularly within a nurse-driven framework. Early removal is a proactive approach that aligns with preventive healthcare principles and underscores the benefits of addressing risks before they manifest (19, 20). Early removal of indwelling urinary catheters IDUCs has been shown to be effective and cost-saving by reducing expenses associated with extended hospitalizations and infection management (14).

Standardized nurse-driven protocols

Consistency in catheter management is critical for delivering high-quality care across healthcare settings. Also, as described in chapter 4, since there are risks associated with urinary catheterization, it is important to ensure that catheters are inserted only when necessary (2). **Chapter 6** presents a study conducted across multiple hospitals aimed at reducing inappropriate urinary catheter use by introducing a standardized protocol nurse-led protocol for perioperative and postoperative care in patients undergoing pituitary and spinal fusion surgeries. By emphasizing the role of nurses in leading catheter-related decisions, this study offers a framework for integrating nursing expertise into clinical practice. These insights empower nurses with the knowledge and tools to take an active role in improving outcomes, while also advancing their professional development and confidence in managing complex clinical situations.

This research demonstrated that the introduction of this new protocol significantly reduced the number of urinary catheters used, which underscores the importance of standardizing care to reduce variations in practice that can lead to discrepancies in patient outcomes. By adopting nurse-led protocols, healthcare facilities can achieve greater consistency, ensuring that all patients receive optimal care (15). In addition to a reduction in the number of urinary catheterizations, it has also been shown that standardized protocols can reduce the incidence of catheter-associated UITs (6). While our study did not find a statistically significant reduction in infection rates, the results are promising and suggest potential for future improvements. However, it is important to acknowledge that reducing variability in practice should not come at the expense of clinical judgment. There are situations where deliberate deviations from the standard protocol—based on patient-specific needs and clinical expertise—are both necessary and beneficial.

One of the key elements in the successful implementation of the standardized protocol in **Chapter 6** was the role of "local champions." These champions—senior nurses who advocated for and supported adherence to the protocol—played a crucial role in driving change and ensuring that the protocol was effectively integrated into daily practice. The value of local champions is well-documented, with research showing that they facilitate adherence reduce resistance to change, and foster a culture of continuous improvement (16). This highlights the importance of incorporating local champions into the implementation of other protocols and innovations, particularly within nursing practice.

Empowering patients

In addition to fluid balance monitoring, postoperative assessment of urine concentration—particularly urine SG—is vital after pituitary surgery, as SG serves as a key indicator for detecting AVP-D (17). Traditionally managed by nurses, patients often lack insight into these values. However, research highlights that when patients actively participate in their care, adherence and outcomes improve (18). Integrating patient involvement also reduces healthcare burdens and enhances quality (19). **Chapter 7** explores self-monitoring of SG through urine test strips, showing that trained patients can accurately monitor SG in over half of cases. This shift allows patients to take greater control over their care, while also transforming the nurse's role from primarily executing measurements to one of oversight and support. This supports a shift toward patient-driven monitoring, enhancing autonomy and aligning with evidence on the safety and feasibility of patient-centered approaches (20).

Limitations and future directions

While this thesis offers valuable insights into the management of urine monitoring in neurosurgical patients, several limitations must be acknowledged. First, the generalizability of the findings may be constrained by the specific patient population studied, which predominantly includes individuals undergoing pituitary surgery. The unique characteristics of this group, such as the possibility of developing the complication AVP-D, may not fully represent the broader hospitalized patient population. However, our findings can serve as a model adaptable to the specific needs of divers patient groups, and the experiences gained from these studies can inform future research design. For example, these strategies could be adapted for orthopedic and general surgery patients, where individualized fluid management protocols are also likely to improve outcomes. Implementing these protocols across different healthcare environments would require comprehensive training programs, ongoing institutional support, and further research to validate effectiveness across diverse patient populations.

Second, this thesis primarily focusses on the immediate postoperative period, with less emphasis on long-term outcomes. While effective urine monitoring is crucial during the early stages of recovery, understanding the long-term impact of these interventions is equally important. Future research should address these limitations by exploring the extended effects of urine monitoring and urinary catheter management strategies.

Third, digital health technologies offer promising ways to extend patient-centered care beyond hospital settings, yet several limitations remain. Practical implementation challenges—such as patient adherence, varying accuracy of self-reported data, and accessibility—may hinder the reliability of these tools. Chapter 7's examination of home urine test strips for specific gravity monitoring reveals that patient self-monitoring may not fully substitute clinical assessments, as it depends heavily on patient engagement and

accurate testing. This limitation suggests that digital solutions might not consistently detect complications like AVP-D, potentially delaying necessary interventions. Future research should rigorously evaluate the effectiveness of digital health tools in supporting patient participation and health outcomes, focusing on factors that influence adherence and the accuracy of self-monitoring practices. Studies could also explore systems that combine digital self-monitoring with remote clinical support, ensuring that nurse-led, patient-centered care remains safe, effective, and beneficial for long-term patient engagement and healthcare resource management.

Conclusion: a new standard in postoperative care

This dissertation proposes a transformative approach to postoperative care that redefines the roles of nurses and patients in urinary monitoring and catheter management. By advocating for nurse-led, patient-centered protocols, this work contributes to a new standard in healthcare—one that prioritizes preventive care, collaboration, and patient empowerment. The findings of this research lay the groundwork for broader adoption of these protocols, not only in neurosurgical settings but across other specialties where urine monitoring is essential to recovery. Empowering nurses as decision-makers and engaging patients as active participants represent more than minor adjustments to current practices; they introduce a fundamental shift toward a healthcare model that is responsive, dynamic, and ultimately more effective. By encouraging the widespread adoption of nurse-led, standardized protocols, healthcare systems can improve clinical outcomes, reduce the incidence of complications, and optimize resource use.

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Chapter 9
English summary

The primary objective of this thesis is to redefine the roles of nurses and patients in routine postoperative neurosurgical care, focusing on empowering autonomy and enhancing collaborative roles. This research is particularly relevant for patients undergoing transsphenoidal pituitary surgery, with some attention to those undergoing spondylodesis surgery. The central themes include urine monitoring, indwelling and intermittent urinary catheters and specific gravity measurements, aiming to improve patient outcomes and healthcare efficiency.

Chapter 2 focuses on exploring the complex decision-making processes behind the removal of indwelling urinary catheters (IDUCs) after transsphenoidal pituitary surgery. Through qualitative interviews with healthcare professionals (HCPs), this chapter delves into the factors influencing these critical decisions. HCPs emphasize the importance of accurate fluid balance monitoring in the immediate postoperative period to manage the risk of postoperative Arginine Vasopressin Disorder (AVP-D). IDUCs facilitate this by providing precise measurements of urine output, but the risks associated with prolonged use, such as urinary tract infections (UTIs), must be balanced against their benefits.

Prolonged use of IDUCs can significantly increase the risk of UTIs, leading to extended hospital stays, increased healthcare costs, and additional patient morbidity. HCPs also highlight the impact of IDUCs on patient mobility and comfort. The presence of an IDUC can restrict patient movement and cause discomfort, hindering recovery. Early removal of the catheter is often desired by patients to enhance their postoperative recovery experience, but this must be weighed against the necessity of accurate urine output monitoring. Nurses play a crucial role in postoperative care, and their workload and ability to manage alternative methods of monitoring urine output are important considerations in the decision to remove an IDUC. This chapter emphasizes the need for evidence-based guidelines to support HCPs in making informed decisions about IDUC removal, advocating for a balanced approach that considers patient safety, comfort, and the efficiency of postoperative care.

Building on the insights from healthcare professionals, **Chapter 3** presents a qualitative study capturing patient perspectives on the use of indwelling urinary catheters and the management of fluid balances after transsphenoidal pituitary surgery. This chapter sheds light on the experiences and views of patients, with the goal of enhancing postoperative care. Patients report mixed feelings about catheter use. While some appreciate the necessity of catheters for accurate monitoring and prevention of complications, others express discomfort and a strong desire for early removal. Patients highlight how IDUCs affect their mobility and daily activities, feeling restricted and uncomfortable, which contributes to a desire for early removal to regain independence and comfort. Clear communication with healthcare providers regarding the necessity and duration of catheter use is crucial for patients, who appreciate being involved in the decision-making process and receiving detailed explanations. The feedback underscores the importance of balancing the clinical benefits of IDUCs with the overall postoperative recovery experience, with early removal, when safely feasible, seen as beneficial for enhancing patient satisfaction and comfort.

In **Chapter 4**, the thesis offers a systematic review of the impact of early postoperative indwelling urinary catheter removal. This chapter synthesizes existing research to evaluate the optimal timing for catheter removal and its effects on patient outcomes. Early removal of IDUCs is generally associated with a significant reduction in the incidence of UTIs. Studies included in the review demonstrate that each additional day of catheterization increases the risk of infection, highlighting the benefits of minimizing catheter

duration. Removing IDUCs early in the postoperative period contributes to improved patient mobility and faster recovery, allowing patients to move more freely without the constraints of a catheter. Enhanced patient comfort is another benefit of early catheter removal, as patients often report feeling more comfortable and less restricted once the catheter is removed. The review identifies the need to balance the benefits of early catheter removal with the potential risks of premature removal, such as urinary retention. It emphasizes the importance of individualized patient assessments and tailored care plans to determine the optimal timing for catheter removal, underscoring the potential benefits of early IDUC removal and calling for further research to solidify these practices in neurosurgical care.

The subsequent chapters shift focus towards strategies aimed at improving perioperative care and reducing complications associated with urinary catheter use in both pituitary and spondylodesis surgeries. Chapter 5 outlines a mixed-methods multicentre study protocol for the de-implementation of urinary catheters during surgery and on the ward. This chapter aims to assess how reducing catheter use impacts patient outcomes, contributing to safer and more effective perioperative care. The study involves multiple centers and combines quantitative and qualitative methods to assess the impact of de-implementation strategies on patient outcomes. By reducing the duration of catheter use, the study aims to lower the incidence of catheter-associated complications such as UTIs and enhance patient comfort and mobility.

The study targets neurosurgical patients who are candidates for reduced catheter use. Inclusion and exclusion criteria are defined to ensure the selection of appropriate participants for the intervention. Data collection methods include a combination of quantitative data collection (e.g., infection rates, catheter duration) and qualitative methods (e.g., interviews with HCPs and patients) to gather comprehensive insights into the effects of the de-implementation strategies. The intervention involves implementing evidence-based protocols to minimize catheter use, such as criteria for catheter placement and removal, staff education, and patient engagement initiatives. The study evaluates a range of outcome measures, including the incidence of UTIs, patient mobility, comfort, and overall satisfaction with care. It also examines the impact on nursing workload and the feasibility of the intervention across different centers.

Chapter 6 discusses the implementation of a standardized protocol, as described in **Chapter 5**, for urinary catheter placement in a multicentre before-and-after study. This chapter evaluates the safety, feasibility, and outcomes of this protocol, aiming to improve postoperative care and reduce unnecessary catheterizations. The study involved 2,711 patients, with 2,167 in the pre-intervention group and 544 in the post-intervention group. The implementation of the protocol increased the percentage of patients without inappropriate indwelling catheterization from 46% to 57%. Additionally, the proportion of patients without inappropriate clean intermittent catheterization (CIC) increased from 34% to 67%. Overall catheter use decreased, with patients not receiving an indwelling catheter rising from 54% to 64%, and those without clean intermittent catheterization increased from 89% to 92%. These improvements were statistically significant, confirming the effectiveness of the standardized protocol in reducing inappropriate catheter use and associated complications.

The ordinal logistic regression analysis showed that the intervention had a statistically significant effect on reducing inappropriate catheter use. The odds of having inappropri-

ate catheter use were significantly lower in the post-intervention group compared to the pre-intervention group, with an odds ratio of 0.65 (95% CI: 0.52-0.81) for IDUCs and 0.48 (95% CI: 0.35-0.65) for CICs. Infection rates showed a slight decrease, dropping from 1.4% to 1.3%, and the average length of hospital stay increased marginally from 4.9 days to 5.1 days. This chapter underscores the importance of implementing evidence-based protocols to improve patient outcomes and enhance the efficiency of postoperative care.

Finally, the dissertation addresses the importance of patient empowerment and participation in managing postoperative complications. Chapter 7 focuses on enhancing patient involvement by simplifying the measurement of specific gravity (SG) after transsphenoidal pituitary surgery. This simplification aims to empower patients to actively monitor their SG levels, which is crucial for early detection of AVP-D, a complication indicated by an SG value below 1005 g/l. This chapter underscores the significance of patient participation in working together with nurses to prevent complications. The study included 110 patients who performed a total of 609 specific gravity measurements using Combur-10® urine test strips and the ATAGO MASTER-SUR/Nα refractometer. Moderate agreement was observed between specific gravity measurements by patients using test strips and refractometer readings, with a Kappa value of 0.47 and an ICC of 0.69. Substantial to good agreement was found between patient and nurse specific gravity measurements when both used urine test strips, with a Kappa value of 0.82 and an ICC of 0.89. Additionally, moderate to good agreement was found between nurse measurements using test strips and the refractometer, with a Kappa value of 0.55 and an ICC of 0.77. A SG threshold of 1.015 g/l for urine test strip measurements was chosen to ensure that no corresponding refractometer results fell below 1.005 g/l, which is critical for diagnosing hypotonic urine. This approach meant that in 57.5% of cases, nurse re-measurement was unnecessary, significantly reducing the workload for nurses and highlighting the effectiveness and reliability of patient-conducted specific gravity measurements.

Patient satisfaction was high, with an average score of 7.8, while nurse satisfaction was lower, at 6.4. Patients expressed confidence in their ability to perform and interpret the measurements, and they valued the sense of empowerment and involvement in their care. Nurses reported that patient involvement helped alleviate their workload and allowed for more efficient use of time and resources.

Conclusion

This thesis aims to optimize nursing policies after transsphenoidal pituitary and spondylodesis surgeries to reduce postoperative complications and empower both nurses and patients to take more active and collaborative roles in their care. Through a series of studies and reviews, the dissertation provides valuable insights into the factors influencing urinary catheter management decisions, patient experiences, and the effectiveness of strategies aimed at improving postoperative care. By addressing these critical aspects, the research contributes to ongoing efforts to enhance the roles of nurses and patients in healthcare, ultimately improving the quality of care and patient outcomes in neurosurgical settings. The findings underscore the importance of evidence-based guidelines, patient and nurse empowerment, and collaborative approaches in enhancing postoperative care. Implementing standardized protocols and involving patients in their care processes can significantly improve outcomes, reduce complications, and enhance patient satisfaction. This thesis provides a comprehensive framework for optimizing postoperative care in neurosurgical settings, paving the way for future research and practice improvements.

Chapter 10
Nederlandse samenvatting

Het primaire doel van dit proefschrift is het herdefiniëren van de rollen van verpleegkundigen en patiënten in de routinematige postoperatieve neurochirurgische zorg, met de nadruk op het bevorderen van autonomie en het verbeteren van samenwerkingsrollen. Dit onderzoek is met name relevant voor patiënten die een hypofyseoperatie ondergaan, met enige aandacht voor degenen die een spondylodese-operatie ondergaan. De centrale thema's omvatten urine monitoring, verblijfskatheters en intermitterende katheters, en metingen van soortelijk gewicht, met als doel de patiëntuitkomsten en de efficiëntie van de gezondheidszorg te verbeteren.

Hoofdstuk 2 richt zich op het verkennen van de complexe besluitvormingsprocessen achter het verwijderen van verblijfskatheters na transsfenoïdale hypofysechirurgie. Door middel van kwalitatieve interviews met zorgprofessionals onderzoekt dit hoofdstuk de factoren die deze kritische beslissingen beïnvloeden. Zorgprofessionals benadrukken het belang van nauwkeurige monitoring van de vochtbalans in de directe postoperatieve periode om het risico op postoperatieve Arginine Vasopressine Deficiëntie (AVP-D) te beheersen. Verblijfskatheters vergemakkelijken dit door nauwkeurige metingen van de urineproductie te leveren, maar de risico's die gepaard gaan met langdurig gebruik, zoals urineweginfecties (UWI's), moeten worden afgewogen tegen hun voordelen.

Langdurig gebruik van verblijfskatheters kan het risico op UWI's aanzienlijk verhogen, wat kan leiden tot verlengde ziekenhuisopnames, verhoogde zorgkosten en extra morbiditeit voor de patiënt. Zorgprofessionals wijzen ook op de impact van verblijfskatheters op de mobiliteit en het comfort van de patiënt. De aanwezigheid van een verblijfskatheter kan de bewegingsvrijheid van de patiënt beperken en ongemak veroorzaken, wat het herstel kan belemmeren. Vroege verwijdering van de katheter wordt vaak gewenst door patiënten om hun postoperatieve herstelervaring te verbeteren, maar dit moet worden afgewogen tegen de noodzaak van nauwkeurige monitoring van de urineproductie. Verpleegkundigen spelen een cruciale rol in de postoperatieve zorg, en hun werkbelasting en vermogen om alternatieve methoden voor het monitoren van de urineproductie te beheren zijn belangrijke overwegingen bij de beslissing om een verblijfskatheter te verwijderen. Dit hoofdstuk benadrukt de noodzaak van evidence-based richtlijnen om zorgprofessionals te ondersteunen bij het nemen van geïnformeerde beslissingen over de verwijdering van verblijfskatheters, waarbij wordt gepleit voor een evenwichtige aanpak die rekening houdt met patiëntveiligheid, comfort en de efficiëntie van postoperatieve zorg.

Voortbouwend op de inzichten van zorgprofessionals, presenteert **Hoofdstuk 3** een kwalitatieve studie die de perspectieven van patiënten vastlegt over het gebruik van verblijfskatheters en het beheer van vochtbalansen na transsfenoïdale hypofysechirurgie. Dit hoofdstuk werpt licht op de ervaringen en opvattingen van patiënten, met als doel de postoperatieve zorg te verbeteren. Patiënten rapporteren gemengde gevoelens over het gebruik van katheters. Terwijl sommigen het nut van katheters waarderen voor nauwkeurige monitoring en het voorkomen van complicaties, uiten anderen ongemak en een sterke wens voor vroege verwijdering. Patiënten benadrukken hoe verblijfskatheters hun mobiliteit en dagelijkse activiteiten beïnvloeden, zich beperkt en ongemakkelijk voelend, wat bijdraagt aan een wens voor vroege verwijdering om onafhankelijkheid en comfort te herwinnen. Duidelijke communicatie met zorgverleners over de noodzaak en duur van kathetergebruik is cruciaal voor patiënten, die het op prijs stellen betrokken te worden bij het besluitvormingsproces en gedetailleerde uitleg te ontvangen. De feedback onderstreept het belang van het balanceren van de klinische voordelen

van verblijfskatheters met de algehele postoperatieve herstelervaring, waarbij vroege verwijdering, indien veilig mogelijk, wordt gezien als gunstig voor het verbeteren van de patiënttevredenheid en comfort.

In **Hoofdstuk 4** biedt het proefschrift een systematische beoordeling van de impact van vroege postoperatieve verwijdering van verblijfskatheters. Dit hoofdstuk synthetiseert bestaand onderzoek om de optimale timing voor katheterverwijdering en de effecten ervan op patiëntresultaten te evalueren. Vroege verwijdering van verblijfskatheters wordt over het algemeen geassocieerd met een significante vermindering van de incidentie van verblijfskatheters. Studies die in de beoordeling zijn opgenomen, tonen aan dat elke extra dag katheterisatie het infectierisico verhoogt, wat de voordelen van het minimaliseren van de katheterduur benadrukt. Het vroeg verwijderen van verblijfskatheters in de postoperatieve periode draagt bij aan verbeterde patiëntmobiliteit en sneller herstel, waardoor patiënten zich vrijer kunnen bewegen zonder de beperkingen van een katheter. Verbeterd patiëntcomfort is een ander voordeel van vroege katheterverwijdering, aangezien patiënten vaak melden zich comfortabeler en minder beperkt te voelen zodra de katheter is verwijderd. De beoordeling identificeert de noodzaak om de voordelen van vroege katheterverwijdering in balans te brengen met de potentiële risico's van voortijdige verwijdering, zoals urineretentie. Het benadrukt het belang van geïndividualiseerde patiëntbeoordelingen en op maat gemaakte zorgplannen om de optimale timing voor katheterverwijdering te bepalen. Dit hoofdstuk onderstreept de potentiële voordelen van vroege verblijfskatheters -verwijdering en roept op tot verder onderzoek om deze praktijken in de neurochirurgische zorg te consolideren.

De daaropvolgende hoofdstukken richten zich op strategieën die gericht zijn op het verbeteren van de perioperatieve zorg en het verminderen van complicaties die verband houden met het gebruik van urinekatheters bij zowel hypofyse- als spondylodese-operaties. **Hoofdstuk 5** schetst een mixed-methode multicenter studieprotocol voor de de-implementatie van urinekatheters tijdens de operatie en op de afdeling. Dit hoofdstuk heeft als doel te beoordelen hoe het verminderen van het gebruik van katheters de patiëntresultaten beïnvloedt, wat bijdraagt aan veiligere en effectievere perioperatieve zorg. De studie omvat meerdere centra en combineert kwantitatieve en kwalitatieve methoden om de impact van de de-implementatiestrategieën op patiëntresultaten te beoordelen. Door de duur van het kathetergebruik te verminderen, streeft de studie ernaar de incidentie van katheter gerelateerde complicaties zoals UWI's te verlagen en het comfort en de mobiliteit van de patiënt te verbeteren.

De studie richt zich op neurochirurgische patiënten die in aanmerking komen voor verminderd kathetergebruik. Inclusie- en exclusiecriteria zijn gedefinieerd om ervoor te zorgen dat geschikte deelnemers voor de interventie worden geselecteerd. Dataverzamelingsmethoden omvatten een combinatie van kwantitatieve gegevensverzameling (bijv. infectiepercentages, katheterduur) en kwalitatieve methoden (bijv. interviews met zorgprofessionals en patiënten) om uitgebreide inzichten te verzamelen over de effecten van de de-implementatiestrategieën. De interventie omvat de implementatie van evidence-based protocollen om kathetergebruik te minimaliseren, zoals criteria voor katheterplaatsing en -verwijdering, personeelseducatie en patiëntbetrokkenheidsinitiatieven. De studie evalueert een reeks uitkomstmaten, waaronder de incidentie van UWI's, patiëntmobiliteit, comfort en algehele tevredenheid met de zorg. Het onderzoekt ook de impact op de werkbelasting van verpleegkundigen en de haalbaarheid van de interventie in verschillende centra.

Hoofdstuk 6 bespreekt de implementatie van het gestandaardiseerd protocol, zoals beschreven in **Hoofdstuk 5**, voor urinekatheterplaatsing in een multicenter voor-en-na-studie. Dit hoofdstuk evalueert de veiligheid, haalbaarheid en uitkomsten van dit protocol, met als doel de postoperatieve zorg te verbeteren en onnodige katheterisaties te verminderen. De studie omvatte 2711 patiënten, met 2167 in de pre-interventiegroep en 544 in de post-interventiegroep. De implementatie van het protocol verhoogde het percentage patiënten zonder ongepaste verblijfskatheters van 46% naar 57%. Daarnaast nam het aandeel patiënten zonder ongepaste intermitterende katheterisatie toe van 34% naar 67%. Het totale kathetergebruik nam af, waarbij het aantal patiënten zonder verblijfskatheters steeg van 54% naar 64%, en het aantal zonder intermitterende katheterisatie steeg van 89% naar 92%. Deze verbeteringen waren statistisch significant, wat de effectiviteit van het gestandaardiseerde protocol bij het verminderen van ongepast kathetergebruik en bijbehorende complicaties bevestigt.

De ordinale logistische regressieanalyse toonde aan dat de interventie een statistisch significant effect had op het verminderen van ongepast kathetergebruik. De kans op ongepast kathetergebruik was significant lager in de post-interventiegroep vergeleken met de pre-interventiegroep, met een odds ratio van 0,65 (95% CI: 0,52-0,81) voor verblijfskatheters en 0,48 (95% CI: 0,35-0,65) voor intermitterende katheterisaties. Infectiepercentages daalden licht, van 1,4% naar 1,3%, en de gemiddelde opnameduur in het ziekenhuis steeg marginaal van 4,9 dagen naar 5,1 dagen. Dit hoofdstuk benadrukt het belang van het implementeren van evidence-based protocollen om de patiëntuitkomsten te verbeteren en de efficiëntie van de postoperatieve zorg te vergroten.

Tot slot behandelt het proefschrift het belang van patiëntempowerment en participatie bij het beheer van postoperatieve complicaties. Hoofdstuk 7 richt zich op het vergroten van de betrokkenheid van patiënten in de neurochirurgie door het vereenvoudigen van de meting van soortelijk gewicht (SG) na een hypofyseoperatie. Deze vereenvoudiging heeft als doel patiënten in staat te stellen hun SG-waarden actief te monitoren, wat cruciaal is voor de vroege detectie van AVP-D, een complicatie die wordt aangegeven door een SG-waarde lager dan 1005 g/l. Dit hoofdstuk onderstreept het belang van patiëntparticipatie in samenwerking met verpleegkundigen om complicaties te voorkomen.
De studie omvatte 110 patiënten die in totaal 609 metingen van het soortelijk gewicht uitvoerden met behulp van Combur-10® urine teststrips en de ATAGO MASTER-SUR/Nα refractometer. Er werd een matige overeenkomst waargenomen tussen metingen van het soortelijk gewicht door patiënten met behulp van teststrips en refractometermetingen, met een Kappa-waarde van 0,47 en een ICC van 0,69. Er was een substantiële tot goede overeenkomst tussen metingen van het soortelijk gewicht door patiënten en verpleegkundigen wanneer beide urine teststrips gebruikten, met een Kappa-waarde van 0,82 en een ICC van 0,89. Daarnaast was er een matige tot goede overeenkomst tussen metingen door verpleegkundigen met teststrips en de refractometer, met een Kappa-waarde van 0,55 en een ICC van 0,77. De drempel van 1.015 g/l voor urine teststripmetingen was gebaseerd op het garanderen dat geen overeenkomstige refractometermetingen onder de 1.005 g/l vielen, wat cruciaal is voor het diagnosticeren van hypotone urine. Deze aanpak betekende dat in 57,5% van de gevallen hertesten door verpleegkundigen niet nodig was, wat de werkbelasting voor verpleegkundigen aanzienlijk verminderde en de effectiviteit en betrouwbaarheid van door patiënten uitgevoerde metingen van het soortelijk gewicht benadrukte.

Patiënttevredenheid was hoog, met een gemiddelde score van 7,8, terwijl de tevreden-

heid van verpleegkundigen lager was, namelijk 6,4. Patiënten gaven aan vertrouwen te hebben in hun vermogen om de metingen uit te voeren en te interpreteren, en ze waardeerden het gevoel van empowerment en betrokkenheid bij hun zorg. Verpleegkundigen rapporteerden dat patiëntbetrokkenheid hielp om hun werkbelasting te verlichten en efficiënter gebruik van tijd en middelen mogelijk maakte.

Conclusie

Dit proefschrift heeft als doel de verpleegkundige beleidsvoering te optimaliseren na transsphenoïdale hypofyse- en spondylodese-operaties om postoperatieve complicaties te verminderen en zowel verpleegkundigen als patiënten te versterken in hun actieve en samenwerkende rol in de zorg. Door middel van een reeks studies en literatuuronderzoek biedt de dissertatie waardevolle inzichten in de factoren die van invloed zijn op beslissingen rondom het gebruik van urinekatheters, de ervaringen van patiënten, en de effectiviteit van strategieën die gericht zijn op het verbeteren van postoperatieve zorg. Door deze kritieke aspecten aan te pakken, draagt het onderzoek bij aan de voortdurende inspanningen om de rol van verpleegkundigen en patiënten in de gezondheidszorg te versterken, wat uiteindelijk de kwaliteit van zorg en de uitkomsten voor patiënten in neurochirurgische settings verbetert. De bevindingen benadrukken het belang van richtlijnen gebaseerd op wetenschappelijk bewijs, empowerment van zowel patiënt als verpleegkundige, en samenwerkingsgerichte benaderingen om postoperatieve zorg te verbeteren. Het implementeren van gestandaardiseerde protocollen en het betrekken van patiënten bij hun zorgprocessen kan de resultaten aanzienlijk verbeteren, complicaties verminderen en de tevredenheid van patiënten vergroten. Dit proefschrift biedt een uitgebreide basis voor het optimaliseren van postoperatieve zorg binnen de neurochirurgie en baant de weg voor toekomstig onderzoek en verbeteringen in de praktijk.

Appendices

List of publications

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Curriculum Vitae

Jeanne-Marie Nollen is op 25 augustus 1993 geboren te Nieuwegein.
Na het behalen van haar Vwo-diploma (profiel economie en maatschappij) aan het Maerlant-Lyceum in Den Haag, startte ze in 2012 op met de bachelor Psychologie in Leiden. Tijdens dit jaar kwam ze tot de conclusie dat deze studie onvoldoende aansloot bij haar interesse in het medische vakgebied. Hierom is ze in 2013 gestart met de opleiding tot HBO-verpleegkunde op de Hogeschool Leiden. Jeanne-Marie is altijd een fervent reiziger geweest en zag door middel van de minor International Health de kans om een semester door te brengen in Bangkinang, Sumatra, Indonesië. Haar afstudeerstage vond in plaats op de afdeling neurologie/neurochirurgie in het Leids Universitair Medisch Centrum (LUMC). Na haar diplomering trad Jeanne-Marie in dienst van het LUMC en combineerde van september 2017 tot juli 2019 haar werk als verpleegkundige op de neurologie/neurochirurgie met de pre-master en aansluitend master Health Sciences aan de Vrije Universiteit van Amsterdam. Tijdens deze master schreef Jeanne-Marie haar scriptie onder leiding van Dr. Wouter van Furth en Dr. Anja Brunsveld-Reinders. Na het behalen van haar masterdiploma in 2019 is Jeanne-Marie gestart aan een PhD-traject dat geleid heeft tot dit proefschrift. Naast dit PhD-traject heeft zij een functie als verpleegkundig expert bekleed waarbij het werk in de praktijk een belangrijke basis en inspiratiebron is gebleken voor haar wetenschappelijk onderzoek.

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