Comparative effectiveness of surgery for traumatic acute subdural hematoma

Essen, T.A. van

PART II

CURRENT PRACTICE

Chapter 4

Neurosurgical treatment variation of traumatic brain injury: evaluation of acute subdural hematoma management in Belgium and The Netherlands

Van Essen TA, de Ruiter GC, Kho KH, Peul WC.

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ABSTRACT

Several recent global traumatic brain injury (TBI) initiatives rely on practice variation in diagnostic and treatment methods to answer effectiveness questions. One of these scientific dilemmas, the surgical management of the traumatic acute subdural hematoma (ASDH) might be variable between countries, between centers within countries and even between neurosurgeons within a center and hence amenable for a comparative effectiveness study. The aim of this questionnaire was to explore treatment variation for ASDH between neurosurgeons in similar centers in a densely populated geographical area. An online questionnaire, involving treatment decisions on 6 case vignettes of ASDH, was sent to 93 neurosurgeons in The Netherlands and Belgium. Clinical and radiological variables differed per case. Sixty neurosurgeons filled out the questionnaire (response rate 65%). For case vignettes with severe TBI and an ASDH there was a modest variation for the decision to evacuate the hematoma and a large variation for the decision to combine the evacuation with a decompressive craniectomy. The main reasons to operate were 'neurological condition' and 'mass effect'. For ASDH and mild/moderate TBI there was large variation for operating or not, whereas 'hematoma size' was the predominant motivation for surgery. Significant intercenter variation for the decision to evacuate the hematoma was observed ($p = 0.01$). Most pronounced was that one out of seven (14%) neurosurgeons in one region chose a surgical strategy compared to nine out of ten (90%) in another region for the same case. In conclusion, variation exists in the neurosurgical management of TBI within an otherwise homogeneous setting. This variation supports the methodology of the international CENTER-TBI initiative and shaped the Dutch Net-QuRe initiative.

Keywords:
Traumatic brain injury, acute subdural hematoma, treatment variation.

INTRODUCTION

Current and future research initiatives in traumatic train injury (TBI) aim to answer effectiveness questions using a comparative effectiveness approach.[1] While most traditional clinical trials have shown disappointing results due to methodological and ethical constraints,[2,3] this comparative effectiveness methodological strategy seems promising for TBI since considerable unexplained variation in outcome has been reported and hypothesized to be due to variation in standard practice care. To relate the practice variation to the outcome variation, however, several of the hypothesized assumptions, imposed by the ambition to do effectiveness research using observational data, have to be explored. Specifically, for many neurosurgical effectiveness questions, mainly regarding severe TBI patients and/or patients with CT abnormalities, practice variation in care has to be present and be quantifiable in the data while at the same time other factors (i.e. confounders) need to be uniformly distributed. Therefore, in preparation for the Dutch Neurotraumatology Quality Registry (Net-QuRe) and Collaborative European NeuroTrauma Effectiveness Research in Traumatic Brain Injury (CENTER-TBI) of one of the important neurosurgical questions, we aimed to explore whether a detailed analysis would lead to a quantification of the hypothesized practice variation in an otherwise homogeneous area. The question entails the clinical dilemma 'to operate or not in acute subdural hematoma (ASDH)'.

When confronted with a patient with TBI and an accompanying ASDH neurosurgeons, are faced with several management dilemmas. The first and most challenging question is whether or not emergency surgery is indicated. The decision whether to evacuate an ASDH is based on a number of factors including the patient's age, Glasgow Coma Score (GCS), pupillary status, comorbidities, computed tomography (CT) findings and subsequent neurological deterioration or not.[4] Prompt surgical evacuation can successfully decrease mortality but it is also known that despite surgical and intensive care treatment many patients die or have an unfavorable functional outcome.[5-8] On the other hand, a substantial portion of patients managed conservatively may have long term favorable outcomes.[9-11]

The second question is whether evacuation of the hematoma should be accompanied by a bony decompression (a decompressive craniectomy, DC). This decision seems to be mainly influenced by the following factors: observation of brain swelling during the surgery, intuitively to be expected secondary brain swelling by the treating clinicians (neurosurgeon, neurologist or intensivist), medically intractable intracranial hypertension in the course of intensive care treatment, presence of penetrating (blast) brain injury or solely as the result of the hospital's protocol.[4,12,13] The known complications of decompressive surgery have to be balanced against the risk of uncontrolled brain swelling.[14,15]

Ethical considerations complicate these decisions even more. Treatment decisions do not merely depend on efficacy based on mortality and functional outcome, but should also consider patient autonomy and incorporate perceived cognitive and somatic disability. Evacuation of the hematoma can be lifesaving but at the same time may lead to survival of severely disabled patients with a poor quality of live or even absence of autonomous cognitive functioning and rational thinking.[16,17]

In addition, these complicated decisions often have to be made in far from ideal conditions, constrained by time, suffering from incomplete information of patients' medical history. And due to 24/7 occurrence, often ensue at difficult moments, in the middle of the night or weekend when regular consultation between senior staff-colleagues is difficult and important treatment choices frequently have to be made by one medical expert, mostly the neurosurgeon on call.

Society, and thereby future patients in particular, will have the opinion that these difficult decisions in TBI management follow protocolled schemes and algorithms, thereby excluding doubt. The contrary of this assumption might however be more true. The surgical decision-making is hampered by the lack of evidence-based selection criteria as a consequence of the absence of robust scientific grounds for surgical indications.[18] The most recent and most broadly known guidelines, The Brain Trauma Foundation (BTF) guidelines on the surgical management of ASDH[4] are deduced from studies with a maximum of - merely - level 3 evidence. Since then, the only study exceeding this level[19] has also not led to clearly defined surgical indications of procedures for patients with an ASDH. Generally, in TBI, there is a lack of high quality evidence relating surgery to outcome, mostly due to methodological constraints.[20,21]

Thus, confronted with a patient with a traumatic ASDH, clinicians have to deal with multiple clinical and radiological variables, in a very limited time frame and with a shortage of data or predictive outcomes. In this setting the training background of the trauma team, the culture of the way treatment is being performed in that particular hospital and the intuition of the neurosurgeon on call could be the most important factors that predict surgical decisions. How this echoes into current practice patterns with possibly variation in TBI management protocols has been scarcely investigated. Hypothetically, no large difference in background and university training of neurosurgeons exists in Belgium and The Netherlands and, therefore, a low practice variation is to be expected. So far, no study has evaluated if this varying trauma management could also be the result of a variable view among neurosurgeons.

Therefore, we performed an online questionnaire study with questions on the clinical management of hypothetical cases, based on real patients with an ASDH, to determine, whether variability in view exists among neurosurgeons on treatment of the ASDH and which potential factors might influence surgical decision-making

by presenting cases that varied for the patient's age, severity (in GCS), thickness of the hematoma and mass effect. The study was conducted in this area with the global goal to evaluate the differences in healthcare provider profile in a hypothetically homogeneous area.

METHODS

The Netherlands and Belgium are small countries with a high population density. Neurosurgical care for patients with TBI is provided at 11 level I trauma centers, serving separate areas according to regional referral policies. Acute trauma care is uniformly organized for all patients, with equal distribution of resources among hospitals. Almost all inhabitants (98%) are within 30 minutes reach from a trauma center (Fig. 1).

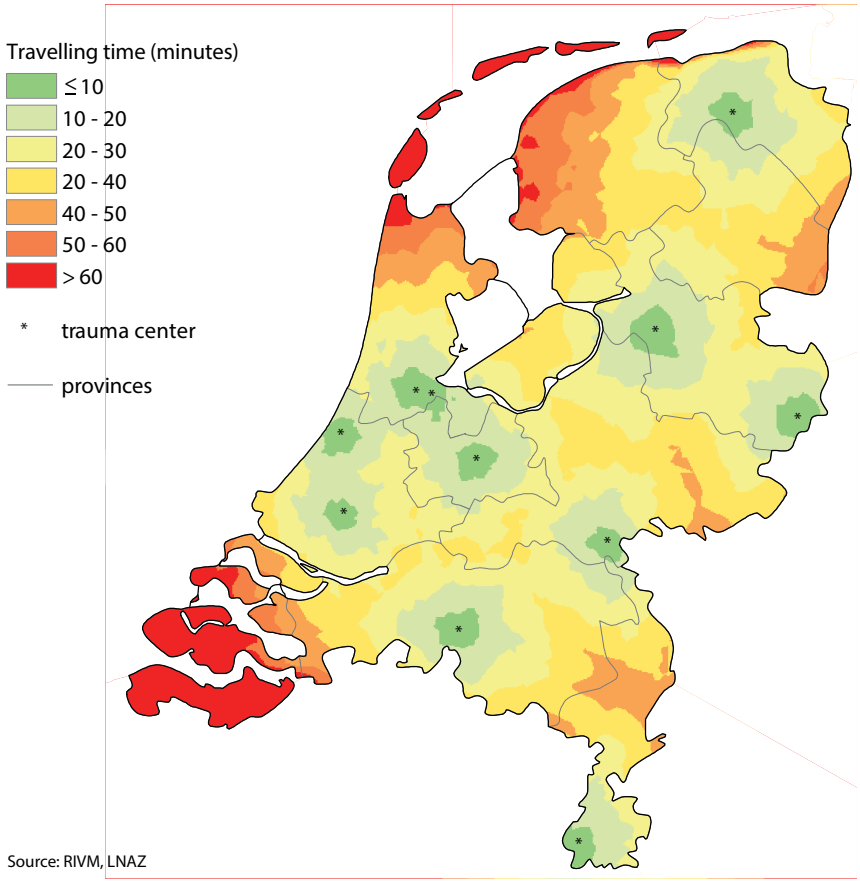


Figure 1. Average traveling time to a trauma center in the Netherlands 2011.

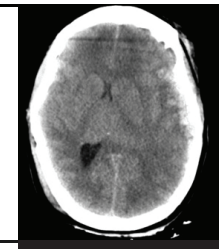
Regular day-to-day cases with TBI and CT brain abnormalities suspecting ASDH were selected. The medical history and CT scans of these patients with traumatic ASDH were retrieved from medical records of Leiden University Medical Center, Medical Center Haaglanden and University Hospitals Leuven. We reviewed these cases and selected 6 cases, based on individual variability between patients, with different medical history, based on severity, age, duration between the accident and presentation to the hospital (Fig. 2). In order to examine potential variation in treatment we selected 4 cases that evoked discussion a priori in the author group and 2 cases that did not (as a control group). Case 1, 2 (control) and 3 represent severe and moderate TBI, i.e. GCS 3-12, and cases 4, 5 (control) and 6 represent mild TBI, i.e. GCS 13-15. The cases were presented in a fixed random order (i.e. equal for every respondent). The provided information per case consisted of the clinical characteristics depicted in Figure 2 and three axial CT coupes (one of which is shown in the figure). In Table 2 the questions regarding these cases are listed.

Dutch and Belgian neurosurgical department chiefs were asked by email whether we could send a survey on operative management of the traumatic acute subdural hematoma to their staff members. An invitation for the online questionnaire was subsequently sent to the staff clinicians, fellows and chief residents working in the responding neurosurgical departments. The online survey was made and disseminated using the web survey tool SurveyMonkey (SurveyMonkey Inc., Palo Alto, California, USA, www.surveymonkey.com).

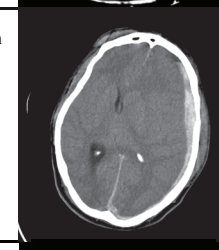
Collected variables of the neurosurgeon were the age, location of residency program, current clinical department and practicing time (time since finishing residency). The various treatment options were analyzed for each case in general (all neurosurgeons). Whether the responders would have operated or not was also analyzed per center (or geographical region) if more than half of the employed staff clinicians responded. The question whether to combine the evacuation with a decompressive procedure, was also regionally analyzed but only for the severe TBI cases (1,2, and 3).

Since the outline of this study was descriptive, only a few statistical analyses were employed. Statistical comparisons were limited to the analysis of regional variation using chi-square test and Fisher's exact test when appropriate. For statistical analysis SPSS 20.0 (IBM, Chicago, Il, USA) was used. P-values < 0.05 were considered to statistical significance. The missing values (not answered questions) for all questions were accepted up to 4% for all questions. Missing data were left out and observed data were analyzed unless stated otherwise.

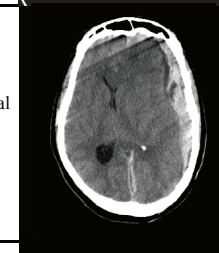
Case 1
Woman, 27 years, motor vehicle accident half hour ago, fall on right side of head.
History: blank. Medication: none.
Neurological exam
E3M5V1, localizes with right arm, not with left arm.
Cranial nerves: normal pupillary reactivity and corneal reflex on both sides.
CT
Left-sided ASDH, contusions left frontotemporal, impression fracture petrous bone right. Midline shift 1 cm to the right. Obliterated basal cisterns.



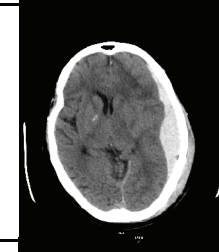
Case 2
Man, 28 years, assault 40 minutes ago, GCS of E1M2V2 and normal pupillary reactivity both sides.
History: unknown. Medication: unknown.
Neurological exam
E1M2V2, no lateralization. Cranial nerves: normal pupillary reactivity on both sides.
CT
Left-sided ASDH, severe midline shift to the right.



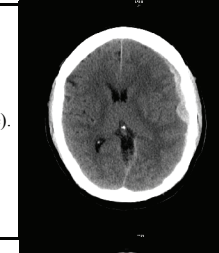
Case 3
Man, 72 years, found unconscious, unclear since when.
History: atrial fibrillation. Medication: acenocoumarol.
Neurological exam
E1M2V1. Cranial nerves: pupil anisocoria (left > right), left pupil nonreactive, normal corneal and oculocephalic reflexes.
Blood results
INR 3,6
CT
Large left -sided ASDH with severe midline shift.



Case 4
Man, 79 years, fall on head couple of hours ago. History: diabetes mellitus and hypertension.
Medication: no anticoagulants, no aspirin.
Neurological exam
E3M6V5. Cranial nerves: no abnormalities.
Motor function: paretic right arm (MRC 4), no other paresis.
CT
Left-sided ASDH of 20 mm. Midline shift 9 mm. Normal basal cisterns.



Case 5
Man, 43 years, assault 2 days ago, headache since then, today nausea and vomiting, no loss of consciousness.
History: aorta insufficiency grade 1 - 2, atrial fibrillation. Medication: acenocoumarol.
Neurological exam
EMV 15. No aphasia. Cranial nerves: normal. Motor function: slight drifting right arm (Barré).
Blood results
INR 2.36.
CT
Left-sided ASDH of 10 mm, midline shift of 5 mm.



Case 6
Woman, 79 years, motor vehicle accident, remembers everything, mild headache without other symptoms.
History: Percutaneous coronary intervention. Medication: aspirin.
Neurological exam
Wound on back of head.
EMV15. No abnormalities.
CT
Left-sided ASDH with mild midline shift to the right. Fracture line caudal side of maxillary sinus.

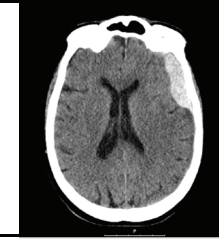


Figure 2. The six case vignettes and the accompanying CTs.

RESULTS

Neurosurgeon's characteristics

The survey was completed by 60 respondents (53 neurosurgeons and 7 chief residents) of a total of 93 invitations send out (response rate 65%). Of the respondents, 43 work in the Netherlands and 17 in Belgium. The responding neurosurgeons work in respectively Amsterdam, Enschede, Leiden/The Hague, Nijmegen, Rotterdam, Tilburg, Antwerp, Brussels or Leuven. Three clinicians did not report their center. The number of clinicians per center is kept anonymous. The respondents had a mean age of 44 years (range 30 – 67) with a median time since finishing residency of 12 years (Table 1).

Strategy towards patients with severe TBI and ASDH

For patients with severe TBI and ASDH (case 1, 2 and 3) there is variation in the decision to surgically evacuate the hematoma or not; respectively 88, 100 and 77 % answered 'yes' to the question 'would you operate or not?' and 23, 8.3 and 28% answered 'yes' to the question 'randomize or not?' (Table 2). The question 'DC or not?' resulted in respectively 74, 67 and 17% of 'yes' answers, indicating variation in type of surgery per case. In addition, respectively 5 (9.4%), 6 (10%) and 2 (4.3%) would choose to perform a DC intraoperatively only when the brain was considered to be swollen. For all other neurosurgeons a craniotomy was the preferred strategy. For the question 'ICP measurement?' respectively 72, 82 and 43% of neurosurgeons answered 'yes'. In case 1 all other neurosurgeons answered 'no' except for eight neurosurgeons (13%) that chose to place an ICP monitor depending on intraoperative brain swelling. In case 2 and 3 all other neurosurgeons did not choose to place an ICP sensor.

Table 1. Baseline characteristics

Responder's characteristics	Number of responders (%)
Number of responders	60 of 93 (65)
Male	55 (92)
Dutch	43 (72)
Age	44, range 30-67
Chief residents neurosurgery	7 (12)
Years since finishing residency	12, 14 IQR

IQR: interquartile range.

Table 2. Questions, possible answers and responses (proportions) with regard to the clinical case vignettes

		Answers (%)					
Questions	**Possible answers**	**Case 1**	**Case 2**	**Case 3**	**Case 4**	**Case 5**	**Case 6**
1. Would you perform an operation on this patient?	*Yes*	53 (88.3)	60 (100)	46 (76.7)	41 (68.3)	3 (5.0)	3 (5.0)
	No	7 (11.7)	0	14 (23.3)	19 (31.7)	57 (95)	57 (95)
2. Would you be willing to leave this decision (whether to operate or not) open for randomization in a study?	*Yes*	14 (23.3)	5 (8.3)	17 (28.3)	29 (48.3)	24 (40)	12 (20)
	No	45 (75) *	55 (91.7)	43 (71.7)	31 (51.7)	36 (60)	48 (80)
3. When answered 'yes' on Q1, what kind of operation would you perform?	*a) Craniotomy with evacuation of the hematoma*	5 (9.4)	14 (23.3)	35 (76.1)	39 (95.1)	2 (66.7)	2 (66.7)
	b) DC with evacuation of the hematoma	39 (73.5)	40 (66.7)	8 (17.4)	0	0	0
	c) Burr hole drainage	0	0	0	0	0	
	d) Another option, please specify: ... **	5 (9.4)	6 (10.0)	2 (4.3)	2 (4.9)	1 (33.3)	1 (33.3)
4. Would you place an ICP sensor?	*Yes*	43 (71.7)	49 (81.7)	26 (43.3)	3 (5.0)	0	0
	No	6 (10)	10 (16.7)	31 (51.7)	56 (93.3)	55 (91.7)	55 (91.7)
	Depends on intraoperative swelling	8 (13.3) *	0 *	0 *	0 *	0 *	0 *

* Numbers do not add up because some respondents did not answer.

** For case 1,2 and 3 the respondents answered that they would perform a decompressive craniectomy dependent on intraoperative swelling. For case 4, 5 and 6 the respondents would start dexamethasone and/or would perform a burrhole drainage in a later stage.

DC: decompressive craniectomy; ICP: intracranial pressure.

Strategy towards patients with mild TBI and ASDH

For the patients with mild TBI and ASDH (case 4, 5 and 6) there is considerable variation in the decision to surgically evacuate the hematoma or not (Table 2; 'operate or not?' respectively 68, 5.0 and 5.0% 'yes' answers; positive incentive for randomization respectively 48, 40 and 20%). DC was never chosen in mild cases. ICP measurement was chosen in three mild TBI cases (5.0% for case 4).

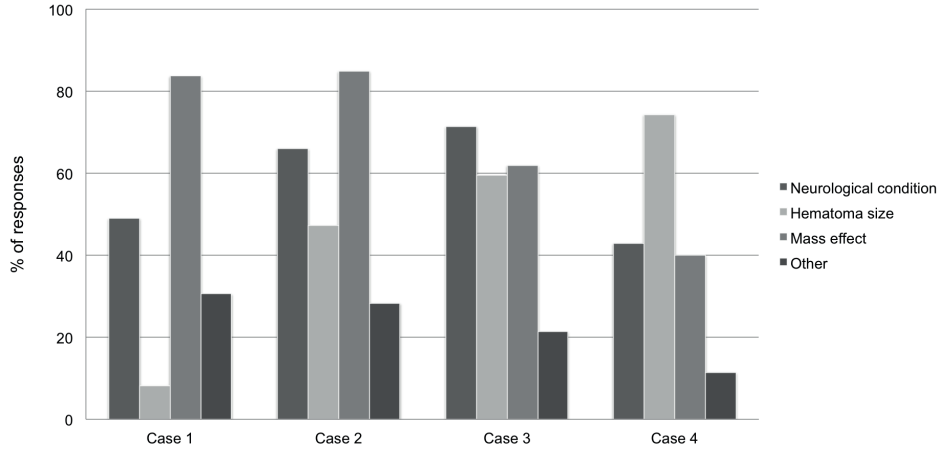


Figure 3. Graph illustrating the reason(s) for evacuation of the acute subdural hematoma, in percentages of responses (proportions).

The respondents had the choice to give multiple answers per case. Case 5 and 6 were not included since a minority of surgeons chose to operate (see Table 2). The numbered cases refer to the cases shown in figure 2.

Table 3. The relation between neurosurgeon's age and tendency to operate

Hypothetically operated (%)	Age		
	≤ 45 yrs	> 45 yrs	*p*
Case 1	31 (93.9)	18 (81.8)	0.20
Case 2	33 (100)	22 (100)	N/A
Case 3	23 (69.7)	18 (81.8)	0.31
Case 4	20 (60.6)	17 (77.3)	0.19
Case 5	2 (6.1)	1 (4.5)	1.0
Case 6	2 (6.1)	0 (0.0)	0.51
Total	111 (56.1)	76 (57.5)	0.80

Five respondents did not report their age. Yrs: years.

Table 4. The relation between region and tendency to operate

Hypothetically operated (%)	Regions					
	A (n = 3)	B (n = 7)	C (n = 16)	D (n = 10)	E (n = 7)	*p*
Case 1	2 (66.7)	6 (85.7)	14 (87.5)	10 (100)	85.7 (6)	0.49
Case 3	1 (33.3)	3 (42.9)	14 (87.5)	9 (90)	7 (100)	0.17
Case 4	0 (0)	1 (14.3)	13 (81.2)	9 (90)	6 (85.7)	0.01

Indications for surgery

For cases representing severe TBI the main reasons for surgery of the ASDH were 'neurological condition' and 'mass effect'. For the operated mild TBI case 'hematoma size' was the most important variable for the decision to operate (Fig. 3).

Age and practice variation

There was no association between age and tendency to operate for all six cases individual or overall (Table 3).

Regional variation

Region is associated with the decision to evacuate the hematoma or not (Table 4). For case 1, the proportion surgical strategies did not differ between regions. For case 3, neurosurgeons in region A and B were less aggressive, although not significantly, with regard to evacuating the hematoma compared to region C, D, and E. For case 4 there was a significant association between region and operating or not. Most notably, one out of seven (14%) of neurosurgeons in one region chose a surgical strategy compared to nine out of ten (90%) in another region for this case vignette. The intracenter variability, i.e. neurosurgeons within a center, is most pronounced for region B, as can also be deduced from Table 4. Lastly, there seems to be a moderate regional variation for the decision to combine the primary evacuation of the hematoma directly with a DC: in case one 57% of region B (n = 7) would perform a primary DC while 100 % of region C (n = 16).

DISCUSSION

Remarkably and in contrast to the author's hypothesis, this study suggests that standard treatment of (severe) TBI is highly variable due to a differing view on neurosurgical management despite the small countries, dense population and similar training curricula of trauma team physicians.

The survey results show that surgical decision making for patients with ASDH varies considerably in the Dutch speaking part of The Netherlands and Belgium. Practice variation in the treatment of ASDH between countries and within large countries like the USA is probable but was not suspected within small countries between hospitals or even between neurosurgeons. The variation in neurosurgical management between regions and between neurosurgeons is quite impressive and cannot be explained by the lack of evidence alone. Ethical considerations, personal opinions about value of a meaningful life from a humanistic perspective probably play an important role. It could be true that the reasons and predictions of clinicians in charge of TBI patients, driving life and death decisions, and, along

that line, how well a neurosurgeon or neurologist can actually predict the outcome, have a profound impact on the prognosis of TBI patients. Therefore, we feel that the different treatment strategies, reflected by the differing opinions in this study, should be related to the true outcome which can best be challenged by a comparative observational study of the different strategies with a comprehensive assessment of the long-term outcome (CENTER-TBI and Net-QuRe).

Specifically, this study shows that there seem to be two groups of TBI-ASDH patients that pose a challenging problem in surgical decision making, namely (1) patients with slight decrease in consciousness, i.e. mild TBI, combined with a large hematoma, and (2) elderly patients with a seemingly poor prognostic profile. These two groups will be discussed separately. A most remarkable finding was the regional variation (Table 4), which forms an important basis for future research on this subject and will be discussed subsequently.

Mild symptoms but large ASDH

The patients with slight decrease in consciousness and a large ASDH (thickness > 10 mm), such as case 4, appear to be a clinical challenge since there was a broad variation in operating or not as well as a high incentive to randomize. Presumably, neurosurgeons in favor of evacuation of the subdural hematoma estimate that a large ASDH leads to neurological deterioration or death by acting to slowly. Their suspicion is backed by the BTF guideline, which was devised in 2005 by an international panel of experts, that states that every ASDH with a thickness more than 10 mm and a midline shift over 5 mm should be evacuated as soon as possible, irrespective of neurological condition.[4] On the other hand, surgeons in favor of a conservative strategy do not want to expose the patient to the risks of a craniotomy without a more precise estimation of the chance of neurological deterioration when withholding an operation. It can be argued that the guideline and the evidence so far should not guide treatment since good quality comparative studies are lacking. Specifically, the reviewed studies of the BTF guideline were of a low level of evidence; retrospective, used small or selected study populations, and were performed more than 10 years ago. Since then, the only study exceeding this level is a Austrian prognostic study[19] Unfortunately, this study included patients with an ASDH due to severe TBI while patients with an ASDH due to mild or moderate TBI were not analyzed. This group represent up to 54% of patients with an ASDH.[9] Consequently, these results have not led to a clearly defined subset of surgical indications of procedures for patients with an ASDH.

Elderly with poor prognosis

The second category of ASDH patients that form a clinical dilemma is the prognostically unfavorable group of the elderly patient with severe TBI (as presented in case 3). Importantly, this clinical dilemma will only become more relevant since the number of elderly patients with a TBI is rapidly increasing[22] and specifically because subdural hematomas are more frequent in older patients.[23]

The treating neurosurgeon chooses not to operate because she/he believes the outcome will still be unfavorable with an operation. On the other hand, the reason to perform surgery could be that a neurosurgeon believes every patient deserves a chance to survive, how unlikely it may be. This tendency to act in severe TBI cases concerns especially young patients. In elderly patients some neurosurgeons are more reserved and abstain from cranial surgery as illustrated in case 3, probably due to an estimated poor prognosis.

To understand the variation in surgical decision-making is to understand the different metrics used to objectify outcome of patients. Clearly, the estimation of an unfavorable outcome or prognosis critically depends on how a worthwhile outcome is valued according to the treating neurosurgeon, trauma-surgeon, intensivist or neurologist. Although functional outcome scales are generally used to determine effectiveness in neurotraumatology studies (i.e. GOSE), neurosurgeons might consider other factors in the clinical setting. Often the conceptual issue quality of life (QoL) is routinely employed in clinical setting, especially in talking about the expected outcome of patients with a severe TBI. The neurosurgeon might estimate that the live that will be saved is not worth living or will result in a low quality of live, and therefore an evacuation is not performed.

In this context it is interesting to see how in a validated QoL instrument performs in ASDH patients. Therefore we performed a 4 year cohort study in Leiden and The Hague in which was shown that ASDH patients with a presenting GCS > 12 do not differ in their long term QoL (as measured by the Qolibri scale[24,25]) compared to surviving ASDH patients with a presenting GCS < 9.[26] This finding relates to the disability paradox where patients with severe disease or disability do not necessarily report a poor QoL.[27]

Surgical decision making in ASDH

Making decisions under uncertainty, especially when time constrained, as is the case for patients with traumatic ASDH, is susceptible for bias [28] and thereby can lead to practice variation. Analyzing the factors associated with this variation will let us understand how the decisions come about and can be improved. The challenges in understanding surgical decision making have been described for patients with spontaneous intracerebral haemorrhage.[29] Each of these issues more or less can also

hamper surgical decision-making in traumatic ASDH. Explicitly, in this investigation, evidence is found for region as an important aggregating factor for the variation in surgical care. The most likely explanation for this result is a differing practice culture between institutions and training background of neurosurgeons.
Also, we like to elaborate on a possible explanation for the discrepancy in the presented variation between severe and mild cases. There was a higher positive incentive for randomization in cases with mild symptomatology (4,5 and 6) than in severe cases (1,2 and 3), possibly reflecting more uncertainty with regard to mild/moderate TBI and ASDH. However, although the percentages 'yes' for surgery in cases 1, 2 and 3 were relatively high, it is important to realize that variation thus exists even for severe neurotrauma cases, in which the decision whether to operate or not often is a matter of life or death. An important explanation could be that neurosurgeons are more convinced of the merits of rapid surgical evacuation in severe cases. In part this might also be explained by a human instinct to act or do something in a patient with a life-threatening condition.

Regional variation in the literature

Although no similar survey has been conducted, other studies have shown that variability in treatment of TBI exists. Rayan et al. showed that in only 17% of a random sample of (brain) trauma patients care was delivered according to the BTF guidelines,[30] suggesting a variable approach. In addition, in an international survey it was shown that there was a difference in point of view among neurosurgeons with respect to combining the evacuation of an ASDH with a DC.[31] Furthermore, intercenter variation in TBI has been shown to exist for referral policy, admission organization, intensive care management (including ICP treatment).[32-38]
The intercenter or regional variation in surgical treatment of ASDH has not been shown in the literature. For other life-threatening or emergency disorders it has been investigated and confirmed for the ruptured abdominal aneurysm[39] and the spontaneous intracerebral haemorrhage.[40]

Strengths and limitations of the study

The main strength of our study is the standardized manner the questionnaire was submitted to medical professionals. Although the senior authors had a strong belief in homogeneous results across neurosurgeons and regions, the study subjects did choose quite differently for the same patient. In the aforementioned studies on current practices in TBI management, variation can be explained by other factors, e.g. by different institutional infrastructure or resources, by divergent patient preferences or by case-mix.

In addition, for the first time the pivotal clinical dilemma whether 'to operate or not' is addressed because case vignettes are presented across the whole spectrum of TBI (GCS 3 to 15). Other studies focus on how care is provided for certain patient subgroups, i.e. with large ASDHs and/or severe TBI. Hence, mainly approaches are evaluated that go into managing high ICP with DC.[31,41] Thus, our study provides insight into the more real-life situation where neurosurgeons are confronted by ASDH patients with heterogeneous clinical and radiological factors.

A very important but inevitable limitation of this study is the set-up as a survey wherein the actual real-life clinical setting is lacking. In the clinical setting the studied decisions often have to be made in far from ideal circumstances with potentially fatal consequences. In contrast, the decisions in this questionnaire are purely complicated by patient characteristics. Nonetheless, while it is acknowledged that this lack of real-life conditions could influence every respondent differently, the main conclusion on variation in ASDH management is most likely justified.

Future direction: comparative effectiveness research

An explanation for the apparent lack of high degree evidence on surgical management for TBI is the difficulty of performing randomized clinical trials. Generally in TBI research, the heterogeneous study population of TBI, i.e. the multitude of patient characteristics and treatment variables, together with small patient numbers make powering clinical trials problematic[21] and, therefore, require an extensive investment of time and money. Specifically for efficacy research of surgical strategies, randomizing surgical treatments for TBI is difficult to perform because of ethical concerns of withholding a potentially lifesaving procedure. In the presented study this is reflected in the low motivation to randomize severe TBI cases. And even if a trial succeeds it regularly has limited external validity since the treatment effect has been evaluated in certain subgroups, with management protocols that are sometimes difficult to replicate in the whole population. The randomized controlled trials on the surgical treatment of TBI, the Decompressive Craniectomy in Patients with Severe Traumatic Brain Injury (DECRA) study[15] and the Surgical Trial in Traumatic Intracerebral Haemorrhage (STITCH-Trauma)[42] trial are examples illustrative of these methodological difficulties.

Due to these methodological challenges, the focus of much TBI research in the last decades has been on suggestions for optimizing RCT design and new study designs in TBI.[2,3] A promising approach could be the so-called comparative effectiveness research (CER). In this design, the heterogeneity and variability, which trouble RCT, are accepted and exploited to study effectiveness of treatments as they occur in real-life practice. This CER analysis of (surgical) treatment for TBI is currently one of the goals of a Dutch initiative called Net-QuRe and an international research initiative

called CENTER-TBI of which the authors are scientific participants (www.center-tbi.eu). The natural existing variation in management shown in this questionnaire provides a strong incentive for such a pragmatic observational study where the variation in surgical strategies is compared between regions and/or neurosurgeons. The rationale for this effort is further strengthened by the fact that the variability in the field of TBI management goes alongside unexplained variability in outcome. In a study by Lingsma and colleagues[43] more than threefold differences were found in the probability over and above chance effects to have an unfavorable outcome between the centers, which could not be explained by adjustments for the most important predictors of outcome in TBI (age, GCS motor score and pupil reactivity). Hence, relating this unexplained variation in outcome to the current practice variation is a promising methodological strategy in the challenging field of TBI research.[2,44]

There is a large variation in management approach for the traumatic ASDH in a medically uniformly trained European region, being The Netherlands and Belgium. Interestingly, there was a regional variation in a surgical versus conservative approach. Ultimately, this variation in management should be exploited in a comparative effectiveness study.

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