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Cotovanu, A.G.M.; Berendsen, R.R.; Dorp, E.L.A. van; Okkerse, P.; Weger, A. de; Blok, A.C.J. de; ... ; Wink, J.

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Original Article

Ultrafast Track Pathway After Low-Risk Cardiac Surgery Enables Intensive Care Unit Stepdown Within 6 Hours: A Feasible Model for Anesthesia-Led Recovery

Alex G.M. Cotovanu*,[2], Remco R. Berendsen, MD*,[2], Eveline L.A. van Dorp, MD, PhD*, Pieter Okkerse, MD, PhD*, Arend de Weger, MD†, Allard C.J. de Blok, MD*, Jeroen A. Janson, MD‡, Mark J. Boogers, MD, PhD§, Jerry Braun, MD, PhD†, Jesper Hjortnaes, MD, PhD†, Jeroen Wink, MD, PhD*,[1]

*Department of Anesthesiology, Leiden University Medical Center, Leiden, the Netherlands
†Department of Cardiothoracic Surgery, Leiden University Medical Center, Leiden, the Netherlands
‡Department of Intensive Care, Leiden University Medical Center, Leiden, the Netherlands
§Department of Cardiology, Leiden University Medical Center, Leiden, the Netherlands

Objective: The aim of this study was to assess the feasibility and safety of the ultrafast track (UFT) integrated care pathway in cardiac surgery patients defined as intensive care unit (ICU) discharge within 6 hours.
Design: A prospective cohort study.
Setting: University Medical Center, the Netherlands.
Participants: A total of 261 adults (median age 70 [62-75], 72.4% male) with EuroSCORE II <3% and additional criteria undergoing elective or urgent coronary artery bypass graft, aortic valve replacement, or mitral valve repair.
Interventions: None.
Measurements and Main Results: UFT completion was achieved in 209 patients (80.1%). 159 (60.9%) patients were extubated in the operating room after surgery. There were 13 reintubations, 12 for the need of a reoperation, and one due to respiratory insufficiency. No patients died within 30 days, and 97% of the cohort was still alive at follow-up. Successful patients had lower postoperative troponin, creatinine, pleural/mediastinal/pericardial drain output, fewer reoperations (1.5% *v* 19.2%) and a shorter hospital length of stay (5 days *v* 6 days).
Conclusion: The UFT protocol including stepdown from ICU within 6 hours after surgery proved feasible and safe to implement in a carefully selected cardiac surgery population and enabled efficient ICU bed turnover without compromising clinical outcomes. This approach may support the broader implementation of fast-track strategies.

Key Words: operating room extubation (OR); ultrafast track; intensive care unit (ICU); cardiac surgery; anesthesia protocol

THE COVID-19 PANDEMIC has placed an unprecedented strain on healthcare systems worldwide, with intensive care unit (ICU) capacities reaching critical limits.[1,2] Consequently, the availability of postoperative ICU beds for elective cardiac surgery was severely limited, effectively

[1]*Address correspondence to:* Jeroen Wink, MD, PhD, Dept. Anesthesiology, H3, Leiden University Medical Center, Albinusdreef 2, 2333 ZA Leiden, the Netherlands.
E-mail address: j.wink@lumc.nl (J. Wink).
[2]A.G.M. Cotovanu and R.R. Berendsen contributed equally to this work.

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halting routine surgical care. Although the nature of postoperative care remained unchanged, the lack of ICU capacity led to widespread postponement of procedures. This situation underscores the vulnerability of traditional ICU-dependent postoperative management and highlights the need to redesign care pathways to safely increase surgical capacity within existing ICU resources.

Fast-track recovery approaches in cardiac surgery have been extensively researched and found to be feasible.[3-6] These approaches include early extubation, commonly defined as occurring within 6 hours after surgery, which is recognized as a central element of the Enhanced Recovery After Cardiac Surgery protocol.[7] Additionally, early extubation has been linked to a reduced risk of complications such as ventilator-associated pneumonia, delirium, and reintubation.[8-10] It has also been shown to facilitate faster postoperative recovery by shortening the ICU stay, improving hemodynamic stability, and reducing the need for sedatives and analgesics.[10-13] These benefits contribute to enhanced patient outcomes and more effective use of resources.[14,15] To address ICU capacity constraints and improve the efficiency of postoperative care, we implemented the ultrafast track (UFT) integrated care pathway for selected cardiac surgery patients. This carefully coordinated strategy was designed to support early recovery by promoting early discontinuation of sedation, reactivation of cortical responsiveness and autonomous control, allowing for early extubation and discharge from the ICU to a step-down unit. By allowing two consecutive cardiac surgery patients to occupy the same ICU bed within a 24-hour period, this protocol increases bed turnover and operational efficiency.

This study aimed to assess the feasibility of the UFT care pathway in promoting rapid recovery and optimizing ICU resources without compromising patient safety.

Methods

We initiated a prospective UFT integrated care pathway for a carefully selected group of cardiac surgery patients, with annual clinical follow-up and progress reporting approved by the hospital's board of directors. Retrospective approval for the publication of anonymized registry data was obtained from the hospital's scientific review board on April 19, 2024 (DAP/tak/0682024). The pathway was structured as a coordinated sequence of steps (Fig. 1): rapid discontinuation of sedation, reengagement of cortical and autonomous responsiveness, early extubation, and expedited transfer from the ICU to a

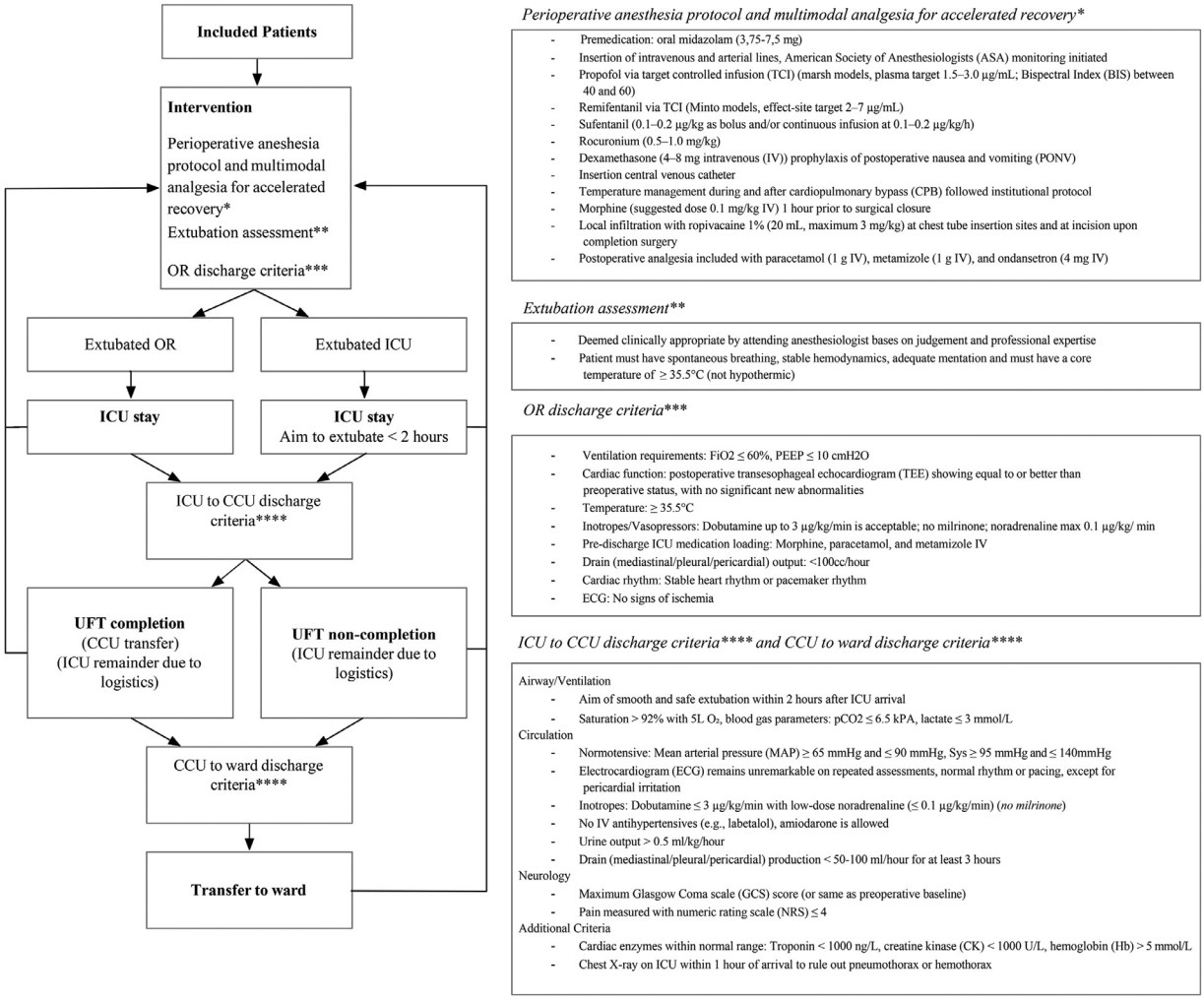

Fig. 1. UFT flowchart and protocol.

step-down unit. To enable transfer to a step-down unit within 6 hours of ICU admission, we targeted extubation either in the operating room or within a few hours of ICU arrival, hence the term "ultrafast track." Although straightforward in concept, the pathway is less predictable in practice, as every step must be aligned for success. We collected and analyzed anonymized data from patients managed using this pathway between January 1, 2021, and December 31, 2024.

Inclusion Criteria for UFT Protocol

Eligible patients were adults under the age of 80 years undergoing elective or urgent (defined as patients admitted non-electively who required a definitive procedure during the current hospitalization and could not be discharged without it) coronary artery bypass graft (CABG) surgery (including LIMA-RIMA-Y procedures), with or without pulmonary vein isolation, aortic valve replacement (AVR), or simple open mitral valve repair (only patients with degenerative mitral regurgitation without annular calcification were considered eligible). To minimize perioperative risk, only patients with a European System for Cardiac Operative Risk Evaluation Score (EuroSCORE) II of <3%[16] and a Cardiac Anesthesia Risk Evaluation (CARE) score of ≤ 2[17] were included. Additional physiological inclusion criteria were as follows: estimated glomerular filtration rate (eGFR) ≥ 60 mL/min/1.73 m^2, a body mass index (BMI) <35 kg/m^2, and chronic obstructive pulmonary disease (COPD) classification of Global Initiative for Chronic Obstructive Lung Disease (GOLD) stage II or lower. Cardiac function had to be well preserved, with left ventricular ejection fraction (LVEF) ≥50% and good right ventricular function (preserved right ventricular function, confirmed by the echocardiographic report and/or a TAPSE measurement of 1.70 cm or higher). Patients with pulmonary hypertension (systolic pulmonary artery pressure ≥30 mmHg) were excluded. The first selection was performed during a multidisciplinary meeting between cardiologists and cardiac surgeons. Patients earmarked as potential UFT candidates were scheduled, if possible, for the first surgical slots of the day to facilitate the timely availability of the same ICU bed for a second cardiac surgery patient later that same day. The week before surgery, the anesthesia team made a definitive decision on patients' eligibility (Fig. 2).

UFT Implementation

Our hospital is a tertiary academic hospital that performs approximately 1,000 cardiac surgeries (750 adult and 250

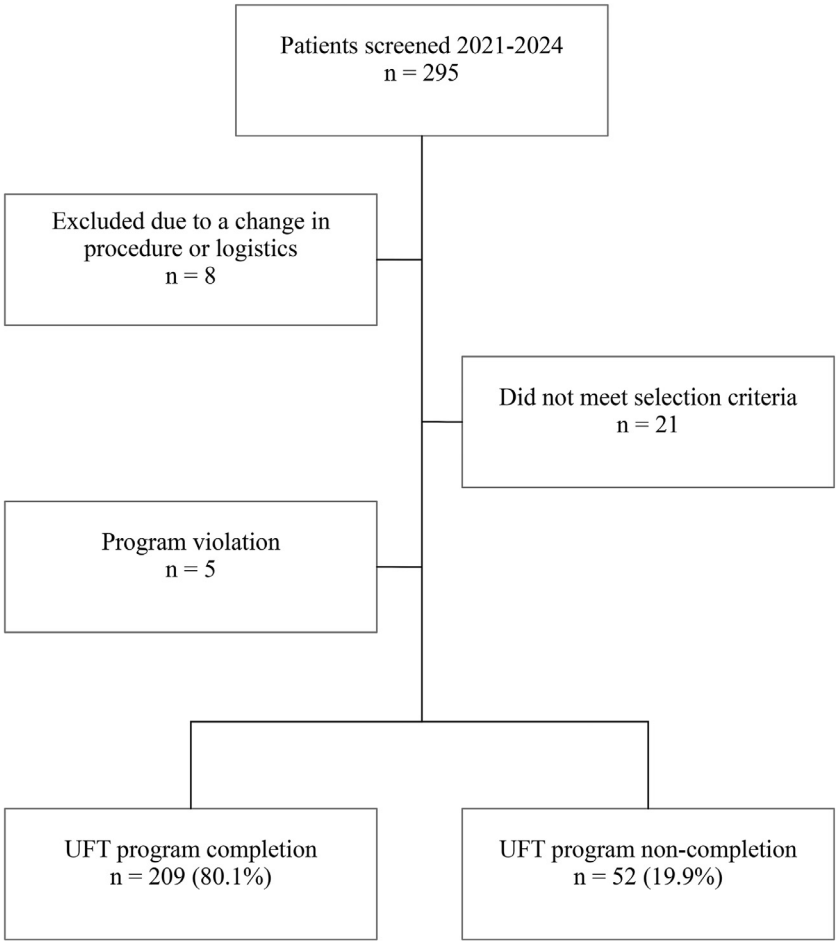

Fig. 2. Flowchart that represents the procedure of the exclusion of the patients. *Excluded for selection criteria: BMI ≥2 patients with >35 kg/m^2, eGFR ≥6 patients with <60 mL/min/1.73^2, LVEF ≥9 patients with <50%, and systolic pulmonary artery pressure ≥3 patients with ≥30 mmHg, urgency ≥1 patient with an emergency procedure.

pediatric cases) annually. In contrast to the ICU, the CCU is not a critical care unit and does not provide mechanical ventilation or mechanical circulatory support (MCS), except for an intra-aortic balloon pump. Depending on patient complexity, the nurse-to-patient ratio for the ICU is 1:1, with a maximum of 1:2, whereas in the CCU it ranges from 1:2 to 1:4. Compared to the ICU, the CCU delivers less intensive care and operates with a lower staff-to-patient ratio, effectively serving as a step-down unit.[18] In this context, the surgeon functions as the primary coordinator of care.

Perioperative Anesthesia Protocol and Multimodal Analgesia for Accelerated Recovery

Anesthesia was administered using a standardized multimodal protocol aimed at rapid emergence and early extubation (Fig. 1, Perioperative anesthesia protocol and multimodal analgesia for accelerated recovery). No strict extubation criteria were applied.

ICU Discharge Criteria for Step-Down Transfer

Eligibility for transfer from the ICU to the step-down unit was assessed using predefined discharge criteria focusing on respiratory stability, hemodynamics, neurological status, and laboratory thresholds, as outlined in Fig. 1 (ICU to CCU discharge criteria). Thresholds for hypertension and hypotension could be adjusted for each patient based on factors such as the surgeon's discretion, specific perioperative complications, or comorbidities that might necessitate different perfusion pressures.

Study Endpoints

Patients were categorized into a "completion group" or a "non-completion group" based on whether they completed the pathway. Completion was defined as ICU discharge within 4 to 6 hours, followed by CCU transfer. Patients who met the discharge criteria but remained in the ICU beyond 6 hours due to capacity constraints in the step-down unit were categorized into the completion group.

The primary endpoint was the feasibility of the UFT-integrated care pathway as determined by the percentage of patients discharged from the ICU within 6 hours. Safety outcomes were incorporated into the secondary outcomes: 30-day reoperation for bleeding or cardiac pathology, 30-day mortality, duration of ventilatory support (defined as early extubation either in the operating room [ORE] or ICU), and hospital length of stay (LOS). Secondary outcomes also included predictors of UFT completion.

Statistical Analysis

Continuous variables were reported as mean ± standard deviation (SD) or median with interquartile range (IQR), depending on the distribution, assessed using the Shapiro-Wilk test. Categorical variables are expressed as counts and percentages. Multivariate logistic regression analysis was performed to identify factors associated with ORE as an outcome. Variables with a p-value <0.2 (see supplement) in a univariate logistic regression were included in the multivariate model. Odds ratios (ORs) with corresponding 95% confidence intervals (CIs) were calculated for each variable. The same approach was applied to analyze factors associated with UFT completion. In multivariate analyses, a confidence interval that did not pass 1.00 was considered statistically significant. Adjustments for collinearity were also performed using the Akaike information criterion (AIC).

Mortality was obtained from the Dutch Heart Registration (NHR, March 3, 2025). For 24 patients, data were missing from the registry. These data were manually retrieved from the hospital's electronic records. The accuracy and completeness of the hospital records were verified by confirming that all known deceased patients were appropriately registered. Following this validation, the mortality dataset was considered complete. The observed mortality rates were compared to those in the Dutch mortality registry. Analyses were performed using R version 4.4.3 (2025; R Foundation for Statistical Computing, Vienna, Austria).

Results

Patient Flow and Cohort

Between January 2021 and December 2024, 295 patients were screened for the UFT program (Fig. 2). During the preoperative admission phase, 8 patients became ineligible due to changes in intervention or procedural planning, and 21 patients did not meet the predefined selection criteria. Among the remaining patients, 5 were excluded due to protocol violations (see Supplement). The final cohort consisted of 261 patients, of whom 209 (80.1%) completed the UFT protocol and 52 (19.9%) did not. Baseline characteristics are presented in Table 1.

Extubation Characteristics

Overall, 159 patients (60.9%) were extubated in the operating room, and 102 patients (39.1%) were extubated in the ICU. Fig. 3 shows a Kaplan-Meier curve of the 102 patients not extubated in the OR, illustrating a steep decline in the proportion of patients still intubated within the first 200 minutes. This figure shows only primary extubations and not reintubations. At 600 minutes, 4 patients were still intubated, all due to extensive bleeding.

In total, 13 patients required reintubation within 30 days: 10 during their ICU stay and 3 after transfer to the surgical ward. Of these, 12 patients were reintubated solely due to reintervention and 1 patient required reintubation due to respiratory insufficiency.

ORE was more frequent in the completion group compared with the non-completion group (63.2% *v* 51.9%). Among patients extubated in the ICU, time from ICU arrival to

Table 1
Baseline Characteristics and Preoperative Variables

	Total Cohort N = 261 (100%)	Completion n = 209 (80.1%)	Non-completion n = 52 (19.9%)
Age (y) median [LQ-UQ]	70 (62-75)	69 (61-74)	72 (67-76)
Sex			
Man, n (%)	189 (72.4)	150 (71.8)	39 (75.0)
Woman, n (%)	72 (27.6)	59 (28.2)	13 (25.0)
BMI (kg/m^2) mean ± SD	26.70 ± 3.28	26.73 ± 3.24	26.56 ± 3.47
Creatinine (μmol/L) mean ± SD	78.51 ± 13.83	77.99 ± 14.00	80.64 ± 13.02
eGFR (mL/min/1.73^2) median [LQ-UQ]	83 (73-90)	83.6 (74-90)	78.4 (71-88)
Diabetes, n (%)			
No	206 (78.9)	157 (75.1)	49 (94.2)
Diabetes, no treatment	2 (0.8)	2 (1.0)	0 (0)
Diabetes, diet	2 (0.8)	2 (1.0)	0 (0)
Diabetes, oral treatment	34 (13.0)	31 (14.8)	3 (5.8)
Diabetes, insulin	17 (6.5)	17 (8.1)	0 (0.0)
Chronic lung disease, n (%)			
No	256 (98.1)	207 (99.0)	49 (94.3)
GOLD 1	4 (1.5)	2 (1.0)	2 (3.8)
GOLD 2	1 (0.4)	0 (0)	1 (1.9)
Recent myocardial infarction, n (%)			
No	231 (88.5)	190 (90.9)	41 (78.8)
Yes <90 days ago	30 (11.5)	19 (9.1)	11 (21.2)
Logistic EuroSCORE 1 (%) median [LQ-UQ]	2.37 (1.61-3.7)	2.21 (1.51-3.10)	3.29 (2.21-4.55)
New York Heart Association class, n (%)			
Class 1	78 (29.9)	64 (30.6)	14 (26.9)
Class 2	154 (59.0)	123 (58.9)	31 (59.6)
Class 3	28 (10.7)	21 (10.0)	7 (13.5)
Class 4	1 (0.4)	1 (0.5)	0 (0)
Urgent procedure, n (%)			
Elective	198 (75.9)	160 (76.6)	38 (73.1)
Urgent	63 (24.1)	49 (23.4)	14 (26.9)
Intervention, n (%)			
Isolated CABG	161 (61.7)	132 (63.6)	29 (53.9)
1 intervention (no CABG)	88 (33.7)	65 (31.1)	23 (44.2)
2 interventions	12 (4.6)	11 (5.3)	1 (1.9)
EuroSCORE 2 (%) median [LQ-UQ]	1.05 (0.74-1.38)	1.04 (0.70-1.34)	1.13 (0.88-1.50)
Multivessel disease, n (%)			
Yes	66 (25.3)	54 (25.8)	12 (23.1)
No	195 (74.7)	155 (74.2)	40 (76.9)
AF, n (%)			
No AF	243 (93.1)	194 (92.8)	49 (94.3)
Paroxysmal AF	11 (4.2)	9 (4.3)	2 (3.8)
Non-paroxysmal AF	7 (2.7)	6 (2.9)	1 (1.9)
Previous percutaneous coronary intervention, n (%)			
Yes	44 (16.9)	37 (17.7)	7 (13.5)
No	217 (83.1)	172 (82.3)	45 (86.5)

Abbreviations: AF, atrial fibrillation; BMI, body mass index; CABG, coronary artery bypass graft; eGFR, estimated glomerular filtration rate; LQ, lower quartile; UQ, upper quartile

extubation was significantly shorter in the completion group (97 [55-128] *v* 256 [117-508] minutes, p < 0.001) (Table 2). There was an increase in ORE rates during the study period (Fig. 4).

ICU Course and Clinical Outcomes

ICU LOS was significantly shorter in the completion group (285 [240-360] *v* 1440 [1340-1570] minutes, p < 0.001). Postoperative troponin (371 [266-555] *v* 494 [378-772] ng/L, p < 0.001), CK (415 [292-557] *v* 447 [324-712] U/L, p = 0.048), and creatinine levels (80 [70-90] *v* 91 [79-106] μmol/L, p < 0.001) were lower in the completion group. Median drain output was also less (235 [145-390] *v* 970 [520-1400] mL, p < 0.001).

Patients in the non-completion group more often received blood transfusions both intraoperatively (37.3% *v* 61.5%, p = 0.002) and postoperatively in the ICU (19.1 *v* 59.6%, p < 0.001) (Table 2).

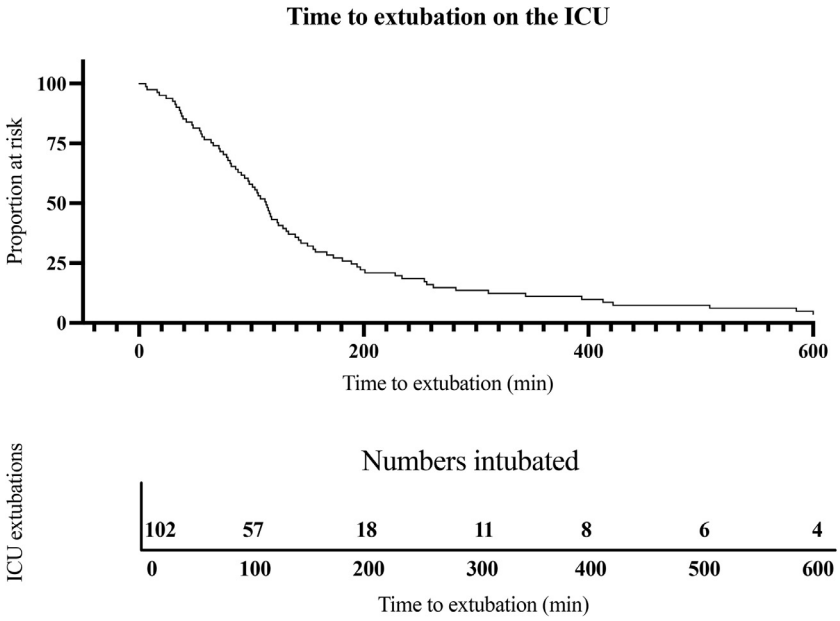

Fig. 3. Kaplan-Meier curve of time to primary extubation in the ICU, showing the proportion of patients not yet extubated over time.

Reoperations and Hospital Stay

Hospital LOS was shorter in the completion group (5 [4-6] *v* 6 [5-9] days, $p < 0.001$). Thirty-day reoperation rates were also lower (1.5% *v* 19.2%, $p < 0.001$), particularly for bleeding or tamponade (1.0% *v* 17.3%, $p < 0.001$).

Survival and Long-Term Follow-Up

At follow-up on March 3, 2025, survival was high in both the completion and non-completion groups: 203/208 (97.1%) and 51/53 (96.2%), respectively. Seven deaths occurred in the entire cohort, none within 30 days. The earliest death occurred at 163 days postoperatively, beyond the 120-day period typically considered procedure-related. The median follow-up time was similar between the two groups (987 [672-1280] *v* 840 [475-1197] days, $p = 0.068$).

Reasons for ICU Remainder

Of 70 patients not transferred to the CCU (Fig. 5), 18 (25.7%) remained in the ICU solely due to limited CCU capacity despite meeting transfer criteria and were categorized into the completion group. Among the 52 patients categorized into the non-completion group, the main reasons for non-transfer to the CCU were postoperative bleeding >100 mL/h for ≥3 hours (28 patients, including 9 reoperations), hemodynamic instability (12 with hypertension, 4 with hypotension), ventilatory support for respiratory insufficiency resulting in a VAP (1 patient), combined bleeding and hypertension (1 patient), ECG abnormalities or elevated cardiac enzymes (3 patients, including one re-graft), pneumothorax/hemothorax (2 patients), and severe anxiety (1 patient).

Predictors of ORE and UFT Completion

Factors associated with ORE as an outcome are shown in Fig. 6A. Higher eGFR (OR 1.023; 95% CI: 1.001-1.046) was associated with increased odds of ORE, whereas perioperative minimum hemoglobin levels (OR 0.613; 95% CI: 0.428-0.863) were associated with decreased odds of ORE (Fig. 6A).

Factors associated with UFT completion are shown in Fig. 6B. Predictors of UFT completion included absence of new oral anticoagulant use (NOAC) (OR 0.109; 95% CI: 0.007-0.704), lower ICU drain output (OR 0.995; 95% CI: 0.992-0.996), and the use of vasopressors (OR 4.129; 95% CI: 1.497-12.631). All patients who used NOACs preoperatively had a drain output of > 500 mL in the ICU.

Discussion

This prospective study is among the few to evaluate the feasibility and safety of the UFT protocol in cardiac surgery. Our approach was notably characterized by assigning a single ICU bed to two patients who underwent surgery on the same day. Our data suggest that such a protocol can be safely implemented in a carefully selected patient population. Outcomes were favorable: there was no in-hospital or 30-day mortality, and survival at follow-up remained high. Compared with national benchmarks for CABG-only patients in the Netherlands (30-day mortality 1.0%-1.4%)[19] and predicted risks of approximately 1% based on EuroSCORE II, our findings appear favorable. However, this likely reflects our strict selection criteria and the small sample size, so caution is advised. This selection was mainly driven by necessity, as the program was intentionally initiated in low-risk patients to ensure a cautious start, emphasizing quality over quantity. Consequently, the cohort had a relatively low EuroSCORE II, which is known to overestimate mortality in such patients, explaining the

Table 2
Secondary Outcomes

	Completion n = 209 (80.1%)	Non-completion n = 52 (19.9%)	p-Value
Extubation in the OR, n (%)			
Yes	132 (63.2)	27 (51.9)	0.137
No	77 (36.8)	25 (48.1)	
Extubation in the ICU: Time to extubation (min) median [LQ-UQ]	97 (55-128)	256 (117-508)	<0.001
Time spent on ICU (min) median [LQ-UQ]	285 (240-360)	1440 (1340-1570)	<0.001
Troponin ICU (ng/L) median [LQ-UQ]	371 (266-555)	494 (378-772)	<0.001
Creatine kinase ICU (U/L) median [LQ-UQ]	415 (292-557)	447 (324-712)	0.048
Drain ICU (ml) median [LQ-UQ]	235 (145-390)	970 (520-1400)	<0.001
Creatinine ICU (μmol/L) median [LQ-UQ]	80 (70-90)	93 (79-106)	<0.001
Time spent in CCU			
0 days, n (%)	18 (8.6)	52 (100.0)	<0.001
1 day, n (%)	187 (89.5)	0 (0.0)	<0.001
2 days, n (%)	3 (1.4)	0 (0.0)	0.385
>2 days, n (%)	1 (0.5)	0 (0.0)	0.617
Hospital length of stay (days) median [LQ-UQ]	5 (4-6)	6 (5-9)	<0.001
Dismiss to, n (%)			
Home	152 (72.7)	42 (80.8)	0.235
Referring hospital	52 (24.9)	9 (17.3)	0.248
Rehabilitation center	5 (2.4)	1 (1.9)	0.840
Reoperations (<30 days), n (%)			
None	206 (98.6)	42 (80.8)	<0.001
Bleeding/tamponade	2 (1.0)	9 (17.3)	<0.001
Cardiac	1 (0.5)	1 (1.9)	0.285
Survival time (days) median [LQ-UQ]	987 (672-1280)	840 (475-1197)	0.068
Mortality status, n (%)			
Alive	203 (97.1)	51 (96.2)	0.705
Deceased	6 (2.9)	1 (1.9)	
Mortality per intervention, n (%)			
CABG	4 (75.0)	0 (0.0)	0.434
AVR	2 (25.0)	1 (100.0)	0.836
Blood products in OR, n (%)			
Yes	78 (37.3)	32 (61.5)	0.002
No	131 (62.7)	20 (38.5)	
Type of blood products in OR, n (%)			
Cell Saver	70 (33.5)	22 (42.3)	0.234
Red blood cells	7 (3.3)	6 (11.5)	0.015
Thrombocytes	14 (6.7)	11 (21.2)	0.002
Blood plasma	3 (1.4)	9 (17.3)	<0.001
Blood products in ICU, n (%)			
Yes	40 (19.1)	31 (59.6)	<0.001
No	169 (80.9)	21 (40.4)	
Type of blood products in ICU, n (%)			
Red blood cells	4 (1.9)	19 (36.5)	<0.001
Thrombocytes	28 (13.4)	23 (44.2)	<0.001
Blood plasma	21 (10.1)	17 (32.7)	<0.001
CPB time (min) median [LQ-UQ]	100 (78-120)	105 (93-135)	<0.001
Cross-clamp time (min) median [LQ-UQ]	75 (55-89)	81 (67-108)	<0.001

Abbreviations: AVR, aortic valve replacement; CABG, coronary artery bypass graft; CPB, cardiopulmonary bypass; ICU, intensive care unit; LQ, lower quartile; OR, operating room; UQ, upper quartile.

discrepancy with the observed outcomes.[20] Our findings align with a recent study, further supporting that ORE after isolated CABG is feasible and safe.[21]

Completion of the UFT protocol was achieved in 80% of patients. The 20% non-compliance rate was largely due to the stringent criteria, particularly regarding postoperative drain output. By design, these rules were conservative to prioritize safety during implementation, but they may also have excluded patients who could have progressed safely through the pathway. For example, nine patients required reoperation for persistent bleeding in the ICU; two were extubated in the operating room after reintervention, and six were successfully transferred to the ward the following day. In hindsight, their initial categorization into the non-completion group may not fully capture the clinical reality. Similarly, 12 patients remained in the ICU because intravenous antihypertensives

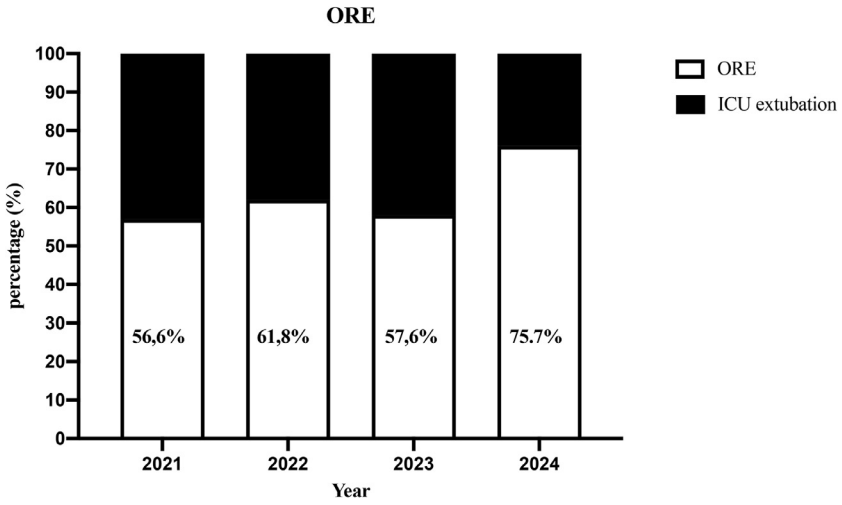

Fig. 4. Percentages of OR per year among the UFT cohort.

were required, even though the CCU is equipped to manage that cardiac pathology. The limiting factor may have been the stringent protocol criteria, rather than clinical instability.

Only a minority of patients (4 of 209, 1.9%) required prolonged ventilation in the ICU, all due to extensive bleeding, as defined by total intubation time >10 hours. Notably, there was one patient who required reintubation due to respiratory insufficiency, which later resulted in a VAP. All other reintubations in the cohort occurred in the setting of a surgical reintervention rather than respiratory compromise. Of the 13 patients requiring reintervention, nine were admitted to the ward the following day, and the remainder were transferred the day after, underscoring the safety of this fast-track pathway.

The anesthetic regimen was designed to enable early extubation. The use of remifentanil in addition to sufentanil enables better hemodynamic control during intense surgical stimuli in cardiac surgery, such as sternotomy.[22,23]

Our logistic regression analysis identified drain output as being associated with UFT completion. At first glance, the odds ratio of 0.995 per 1 mL seems trivial, but above 100 mL, the odds ratio drops to about 0.61. This means that the odds of

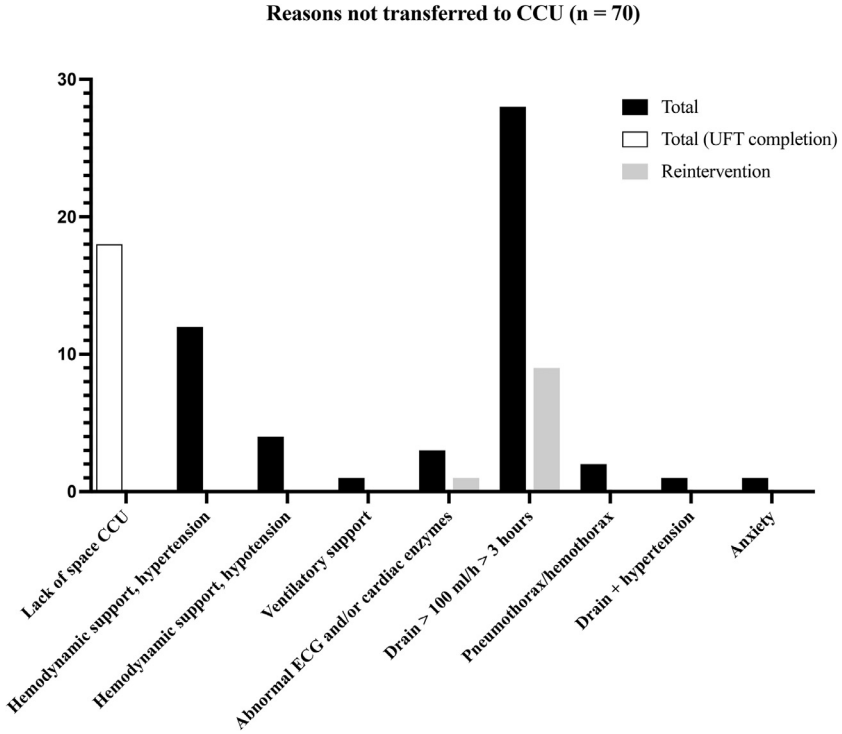

Fig. 5. Column with reasons for not being transferred to CCU.

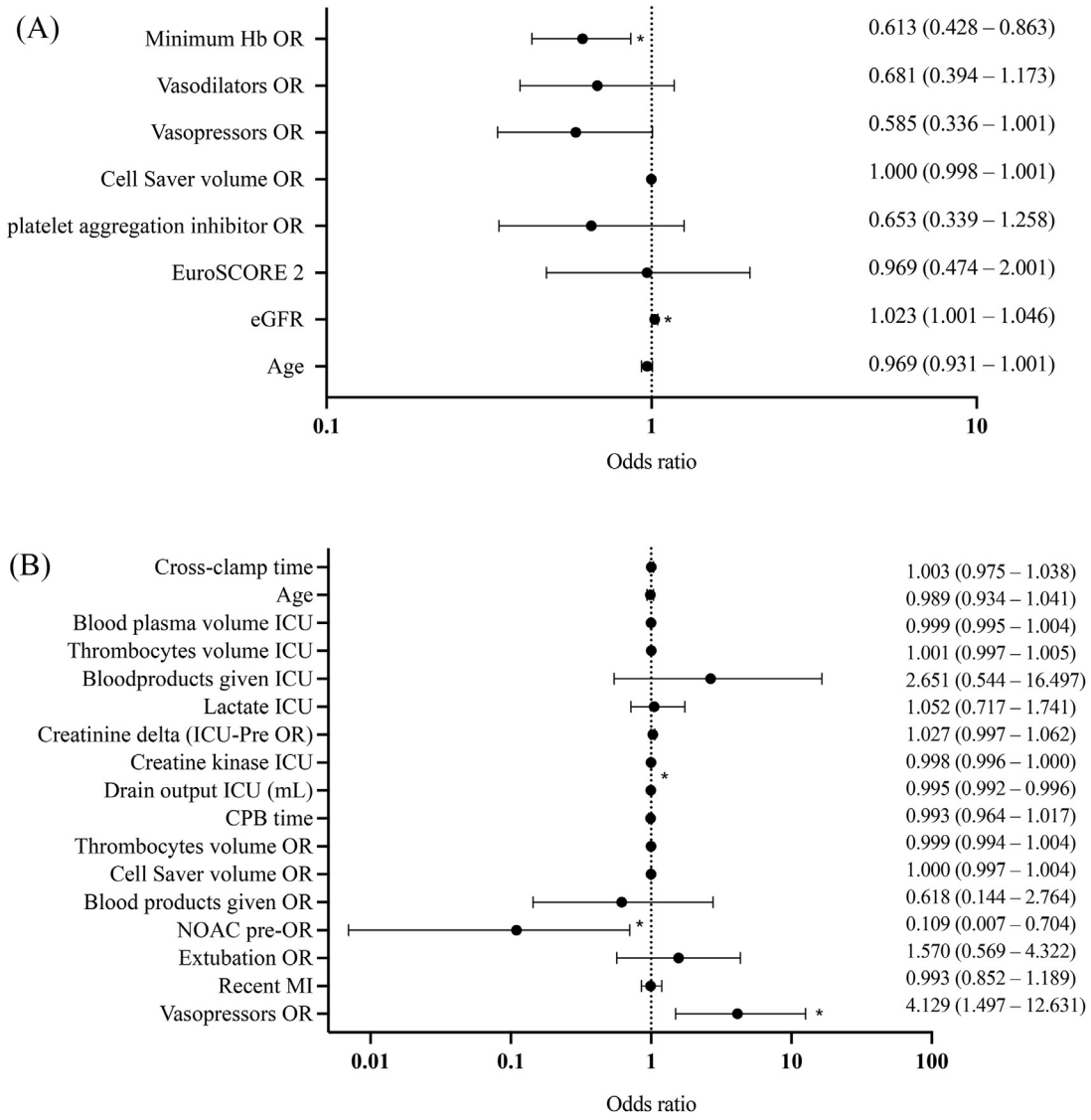

Fig. 6. (A) Multivariate analysis of predictors for OR with odds ratios and 95% confidence intervals. (B) Multivariate analysis of predictors for UFT completion with odds ratios and 95% confidence intervals. *Statistically significant predictors.

UFT completion decrease by nearly 40% with every additional 100 mL of blood loss, a difference that is both clinically meaningful and frequently encountered in practice. However, while some degree of drain output is expected during the postoperative course, excessive output primarily reflects complications such as bleeding. It is therefore not an independent predictor that can be used intraoperatively to guide decision-making. A similar nuance applies to renal function; higher eGFR was associated with increased odds of ORE, with an OR of 1.023 per mL/min/1.73 m^2. A difference of 10 to 20 mL/min/1.73 m^2 can alter the probability of ORE. This suggests that renal function might have some predictive value. However, the effect size is small and unlikely to translate into broadly generalizable prediction models. In line with earlier studies, our data suggest that fast-track outcomes such as ORE and eventual UFT completion remain difficult to predict from standard clinical variables and appear to be largely patient-specific.[24-28] This emphasizes the need for a personalized strategy in perioperative decision-making and may reflect the influence of unmeasured variables yet to be identified.

Some laboratory findings were statistically associated with ORE or UFT completion but lack clinical weight. Postoperative troponin and creatinine levels were lower in the UFT completion group, but the absolute differences were not clinically relevant. Our local threshold for clinically relevant troponin is 1,000 ng/L, with some studies indicating relevance starting from 1,600 ng/L.[29] This is well above the observed values. Likewise, KDIGO (Kidney Disease: Improving Global Outcome) criteria for acute kidney injury require a ≥1.5-fold increase from baseline postoperatively or an absolute increase of ≥ 26.5 μmol/L within 7 days after surgery,[30,31] neither of which apply here. Furthermore, minimum perioperative hemoglobin levels are negatively associated with ORE. However, this finding is also unlikely to be clinically meaningful, as the

transfusion threshold in cardiac surgery starts at Hb levels of less than 8 g/dL (±5 mmol/L),[32] and only 10 patients in our cohort had values below this level. Preoperative NOAC use was strongly associated with reduced odds of UFT completion (OR 0.109). This likely reflects the increased bleeding risk associated with NOACs, which may delay hemodynamic stabilization and thereby impede UFT completion. Consistently, all patients who received NOACs had a postoperative drain output exceeding 500 mL.

Clinical Implications

The implementation of the UFT protocol in selected cardiac surgery patients shows that, with strict selection and coordinated perioperative management, early extubation and rapid ICU discharge are feasible and can be achieved without compromising patient safety. In practice, this allows more efficient use of scarce ICU resources and may help preserve surgical capacity during times of system strain, as seen during the COVID-19 pandemic. In our hospital, the UFT program permitted a maximum of three UFT patients per week, and these patients had to be scheduled as the first cases of the day, which limited the number of eligible participants. Analysis of our adult cardiac surgical population shows that 20% to 25% of the population meets the UFT criteria, indicating that the UFT protocol could have a substantial impact on ICU utilization and the overall cost of perioperative care. Fast-track recovery and early extubation have been advocated for over a decade, with anesthetic management and patient selection consistently identified as critical determinants of success.[33] Expert consensus still acknowledges that optimal strategies remain unsettled,[34] yet a gradual normalization of ORE is taking place. Our experience mirrors this trend. The UFT protocol not only increased the proportion of ORE (Fig. 4), but also shifted local practice, extending readiness for immediate extubation to more complex procedures, including type A dissection repair.

Such observations suggest that institutional confidence and structured pathways can drive broader adoption of fast-track programs. Still, the path requires infrastructure, interdisciplinary coordination, and a culture of shared responsibility. It also has limits: in critically ill patients, rigid protocolization is rarely appropriate and may even be harmful. Individualized decision-making remains essential, shaped not only by anesthesia expertise but also by the bedside judgment of the ICU team overseeing the immediate postoperative phase.

Limitations

Several limitations warrant attention. This was a single-center study, and although our patient mix and perioperative protocols resemble those of many tertiary centers, generalizability may be limited. The strict inclusion criteria yielded a relatively healthy cohort with a low predicted risk, enhancing safety but limiting its application to higher-risk populations. The absence of a contemporaneous control group limited the ability to attribute the observed outcomes solely to the UFT protocol. Furthermore, low event rates limit the power to detect uncommon complications. Although we defined outcomes such as mortality and reoperation clearly and objectively, other endpoints—including timing of extubation and readiness for discharge—partly depended on clinical judgment, potentially introducing subjectivity. In addition, the Hawthorne effect might have inflated apparent completion rates in the present study; implementing and studying a new pathway may have influenced behavior. ICU nurses and anesthesiologists may have paid closer attention to extubation readiness or communicated more actively than they would under routine conditions. Such changes could improve outcomes independently of the protocol itself. The transition of ICU care toward managing nonventilated postoperative patients also represents an organizational shift, and its success relies heavily on nursing adaptation and interdisciplinary communication. While more detailed activity-level time stamps could have clarified early recovery, this feasibility study focused on whether early transfer and safe step-down unit accommodation were possible. We used broad postoperative milestones instead of a structured mobilization schedule, and future studies will likely include more granular activity markers to better assess recovery. Finally, while TCI-based anesthetic administration may have influenced recovery times,[35,36] we believe that drug titration and timely discontinuation of infusions are more decisive than the infusion model itself.

Future Research

Future research should ideally focus on comparative studies. For example, by matching UFT-selected patients to a historical control group, to better isolate the protocol's effect on outcomes. Beyond hard clinical endpoints, such designs could shed light on resource utilization, patient satisfaction, and complication rates, thereby clarifying both the clinical and economic value of fast-track care in cardiac anesthesia. These data could help identify predictors of which patients benefit most from the UFT protocol. Additionally, expanding the present study to include multiple centers and a more diverse patient population would reduce the Hawthorne effect and enhance generalizability. Finally, long-term follow-up, incorporating patient-reported outcome measures and patient-reported experience measures, could further elucidate functional recovery and late complications, thereby enriching the evaluation of the UFT protocol's overall impact.

Conclusion

This study demonstrates that our UFT program is a safe and feasible strategy for selected patients undergoing cardiac surgery, contributing to more efficient utilization of hospital resources. Observed mortality rates were low and consistent with those reported in the existing literature. While promising, these results reflect a low-risk cohort, and it remains uncertain whether similar outcomes can be achieved in higher-risk populations.

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Declaration of competing interest

The authors have nothing to disclose.

CRediT authorship contribution statement

Alex G.M. Cotovanu: Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Remco R. Berendsen:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Eveline L.A. van Dorp:** Writing – review & editing, Validation, Software, Methodology, Formal analysis, Conceptualization. **Pieter Okkerse:** Writing – review & editing, Validation, Investigation. **Arend de Weger:** Writing – review & editing, Validation. **Allard C.J. de Blok:** Writing – review & editing, Validation, Investigation. **Jeroen A. Janson:** Writing – review & editing, Validation. **Mark J. Boogers:** Writing – review & editing, Validation, Conceptualization. **Jerry Braun:** Writing – review & editing, Validation, Conceptualization. **Jesper Hjortnaes:** Writing – review & editing, Validation, Supervision, Methodology, Conceptualization. **Jeroen Wink:** Writing – review & editing, Writing – original draft, Validation, Supervision, Methodology, Conceptualization.

Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1053/j.jvca.2025.12.007.

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