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On-table extubation is associated with reduced intensive care unit stay and hospitalization after trans-axillary minimally invasive mitral valve surgery

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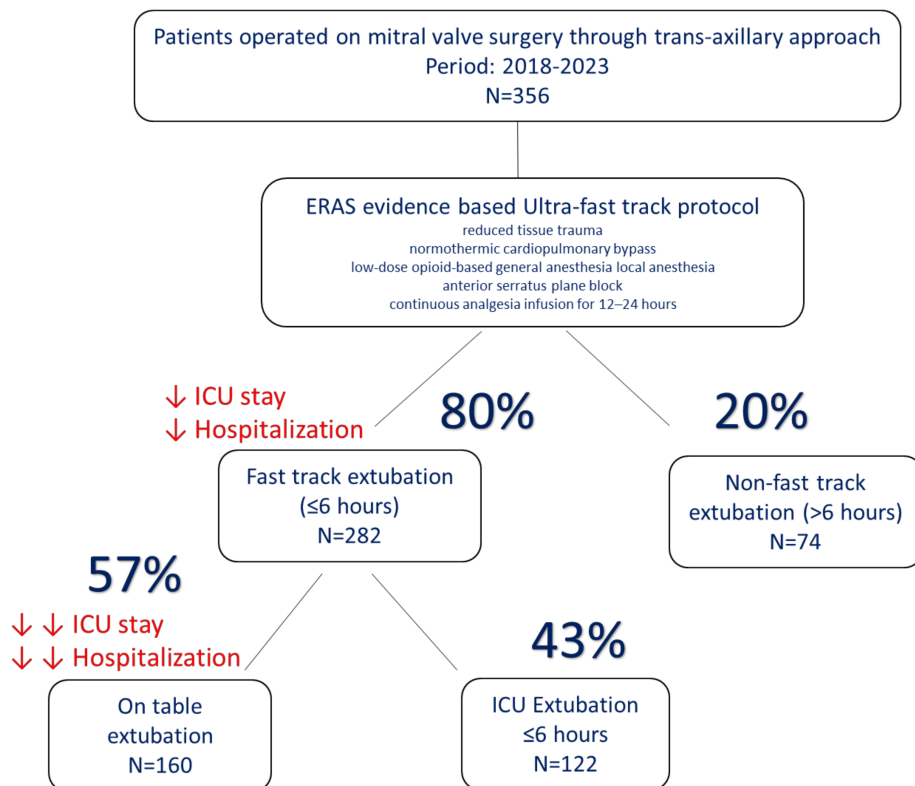
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(Article begins on next page)

On table extubation reduces ICU stay and hospitalization after trans-axillary minimally invasive mitral valve surgery

Summary

Fast track extubation was achievable in most of the patients undergoing trans-axillary minimally invasive mitral valve surgery and was associated with higher rates of day 1 Intensive Care Unit discharge and discharge home. On table extubation was associated with further reduced Intensive Care Unit stay and hospitalization.



1 **Title: On table extubation is associated with reduced Intensive Care Unit stay and hospitalization after**
2 **trans-axillary minimally invasive mitral valve surgery**

3 **Running title: Early extubation in trans-axillary mitral valve surgery**

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20

21 **Visual abstract**

22

23 **Key question:** Does on table extubation offer any advantage in trans-axillary mitral valve surgery?

24 **Key findings:** On table extubation within an ultra-fast track protocol is associated with reduced postoperative
25 ICU and hospitalization.

26 **Take-home message:** Protocols including early extubation in trans-axillary mitral valve surgery are safe and
27 contribute to a shorter patients' hospitalization.

28

Abstract

Objectives. Few data are available regarding early extubation after mitral valve surgery. We sought to assess the impact of an Enhanced Recovery After Surgery based protocol – ultra-fast track protocol – in patients undergoing minimally invasive trans-axillary mitral valve surgery.

Methods. Data of patients who underwent trans-axillary mitral valve surgery associated with ultra-fast track protocol between 2018 and 2023 were reviewed. We compared preoperative, intraoperative and postoperative data of patients who had fast track extubation (≤ 6 hours since the end of the procedure) and non-fast track extubation (> 6 hours) and, within the fast track group, patients who underwent on table extubation and patients who were extubated in Intensive Care Unit within 6 hours. Multivariable logistic regression was used to study the association of extubation timing and Intensive Care Unit stay, postoperative stay and discharge home.

Results. Three-hundred fifty-six patients were included in the study. Two-hundred eighty-two patients underwent fast track extubation (79%) and 160 were extubated on table (45%). We found no difference in terms of mortality and occurrence of major complications (overall mortality and cerebral stroke 0.3%) according to the extubation timing. Fast track extubation was associated with shorter Intensive Care Unit stay, discharge home and discharge home within postoperative day 7 when compared to non-fast track extubation. Within the fast track group, on table extubation was associated with Intensive Care Unit stay ≤ 1 day and discharge home within postoperative day 7.

Conclusions. Fast track extubation was achievable in most of the patients undergoing trans-axillary minimally invasive mitral valve surgery and was associated with higher rates of day 1 Intensive Care Unit discharge and discharge home. On table extubation was associated with further reduced Intensive Care Unit stay and hospitalization.

Abstract word count: 274

Keywords: ERAS, mitral valve, mitral valve repair, mitral valve replacement, minimally invasive surgery

55 **Introduction**

56 Early extubation after cardiac surgery was popularized in the late 1990s (1,2) and has subsequently been
57 shown to be safe (3) and associated with reduced postoperative ICU and hospital stay particularly in the
58 context of CABG and minimally invasive heart valve surgery (4-8). More recently Enhanced Recovery after
59 Surgery (ERAS) protocols have been applied to cardiac surgery to improve patients' experience allowing
60 shorter postoperative stays, reduced rate of transfusion and enhanced pain management (9). A growing
61 number of observational and RCTs studies reported satisfactory early results with improved outcomes,
62 reduced cost and increased satisfaction in patients operated on following institutional ERAS protocols (10-
63 13). However, they mainly included small size populations with mixed cardiac surgery procedures and a
64 limited number of mitral valve procedures.

65 In the last 5 years, we have developed and favoured the trans-axillary (TAXA) approach for our minimally
66 invasive mitral valve surgery program. We have recently reported the results of the experience shared with
67 the Unit of Cardiac Surgery of Dresden and found that TAXA surgery was performed with contained operative
68 times and was associated, when compared with full sternotomy approach, with shorter mechanical
69 ventilation length, postoperative stays, and discharge home without any further period of cardiopulmonary
70 rehabilitation (14). Since 2016, we have also established an ERAS ultra-fast track protocol that has shown to
71 be safe and associated with reduced rates of respiratory insufficiency and delirium, with shorter lengths of
72 stay and with lower rates of early mortality and postoperative complications (15). The reduction of tissue
73 and biological trauma represents one of the cornerstones of this protocol alongside normothermic CPB, low-
74 dose opioid-based anaesthesia, aggressive pain management, early extubation and mobilisation.

75 The aim of this study was to assess the impact of ultra-fast track protocol in patients undergoing trans-axillary
76 mitral valve surgery and to ascertain whether on table extubation is associated with any further advantage
77 in the postoperative course.

78

79

80 **Materials and methods**

81 *Population*

82 The population of this study included consecutive patients who underwent first-time trans-axillary mitral
83 valve surgery associated with an ultra-fast track protocol at our academic centre during the period January
84 2018 – April 2023.

85

86 *Ethical statement, study design, data collection*

87 This study is a single centre retrospective outcome evaluation from institutional records with prospective
88 data entry. Patients' data were retrieved from the internal database of Cardiac Surgery Unit at Lancisi
89 Cardiovascular Centre in Ancona (Italy) (approval CERM 2019 361). Several preoperative, intraoperative and
90 postoperative data were collected.

91

92 *Definitions*

93 The definition of preoperative characteristics aligns with the notes about EuroSCORE (16). Early mortality
94 and complications refer to events that occurred in the first 30 days since the operation. Postoperative
95 outcomes were recorded according to the VARC-2 criteria (17).

96 The timing of extubation was used to characterise two groups of patients:

- 97 • ***Fast track group***: extubation within 6 hours since the end of the operation (18). This group was
98 further characterised by considering patients who had on table extubation (*On table extubation*
99 *subgroup*) after the end of surgical procedure and patients extubated in ICU within 6 hours
100 (*Extubation ≤ 6 hours in ICU*).
- 101 • ***Non-fast track group***: extubation after 6 hours since the end of the operation.

102

103 *Aims and Endpoints*

104 Aim of this study was to ascertain whether early extubation and on table extubation in patients undergoing
105 minimally invasive mitral valve surgery are feasible, safe and potentially associated with any relevant clinical
106 advantage. We assessed the following endpoints:

- 107 • Length of ICU (postoperative day 1 discharge from ICU) and global postoperative hospital stay
108 (postoperative day 7 discharge from hospital), destination at the discharge (home vs medical or
109 rehabilitation centre) according to Fast track and Non-fast track extubation, On table extubation and
110 Extubation≤6 hours in ICU;
- 111 • 30-day outcomes (mortality, postoperative complications) according to Fast track and Non-fast track
112 extubation, On table extubation and Extubation≤6 hours in ICU.

113

114 *Ultra-fast track protocol*

115 The ultra-fast track protocol for heart valve surgery has been used since 2016 in our institution (15,19). This
116 was generated based on enhanced recovery after surgery evidence (18,20) and developed within a
117 multidisciplinary team including surgeons, anesthesiologists, perfusionists, physiotherapists, nurses, and
118 families. The key features of the protocol include:

- 119 • the reduction of tissue trauma through reduced chest incision as we favor trans-axillary approach
120 with no ribs spreader for mitral valve surgery;
- 121 • normothermic cardiopulmonary bypass management;
- 122 • low-dose opioid-based general anesthesia with short-acting volatile agent (sevoflurane) to maintain
123 anaesthesia;
- 124 • pain management through pre-operative single-shot anterior serratus plain block, local infiltration
125 of sutures and drain sites, post-operative continuous serratus plain block for 24-48 hours and
126 continuous analgesia infusion for 12-24 hours (tramadol 4-8 mcg/kg/min).

127 This setup was invariably used in all the patients undergoing minimally invasive mitral valve surgery aiming
128 for:

- 129 • on table extubation at the end of the surgical procedure;
- 130 • respiratory therapy starting at 3–6 hours after extubation and mobilization at 6–12 hours including
131 bed exercises, bed and chair sitting, standing position, assisted ambulation;
- 132 • oral feeding at 6–12 hours after surgery;
- 133 • patient-family contact (3 hours after extubation);
- 134 • drain removal in postoperative day 1;
- 135 • day 0 or 1 discharge from ICU.

136 The following criteria were used for extubation: patient alert, awake and able to follow commands;
137 hemodynamic stability without inotropic support; no bleeding (as evaluated by the surgeon during and soon
138 after the closure the mini-thoracotomy access), hemoglobin > 10 g/L; body temperature > 36°C; spontaneous
139 breathing with respiratory rate < 30/min; appropriate acid-base status; PaCO₂ < 50 mmHg, PaO₂ > 60 mmHg
140 (with a maximal FiO₂=50%), SpO₂ > 95%, tidal volume 5-10 ml/kg.

141 Supplemental table 1 summarizes the ultra-fast track protocol.

142

143 *Surgical techniques and cardiopulmonary bypass*

144 All patients received general anaesthesia and TOE was performed before and during the operation for
145 monitoring and evaluation of the surgical result. The trans-axillary access was performed as described
146 previously (14). Shortly, with the patient on supine position, a 4 to 5 cm skin incision was made in the right
147 anterior axillary line at the level of the 4th intercostal space. Cardiopulmonary bypass was established through
148 femoral vessels cannulation using Seldinger technique and TOE guidance after surgical cut-down. The right
149 jugular vein was cannulated before surgical draping. The cardiopulmonary bypass was conducted maintaining
150 normothermia after cannulation of the common femoral artery (3/8" line and a 18-22 French cannula, to

allow a cardiac index of 2.4l/min * body surface area), the femoral vein (1/2" venous line with a 15-27 French multi-stage cannula) and the right internal jugular vein (3/8" line and a 16-18 F cannula). Centrifugal pumps and a membrane oxygenator with integrated arterial filter were used in all the cases. Vacuum-assisted venous drainage was invariably adopted with a mean pressure of [-20, -25] mmHg and never exceeding the value of -40 mmHg. The aorta was occluded using a flexible clamp introduced through the mini-thoracotomy access and crystalloid cardioplegia was then delivered through a needle in the ascending aorta. Histidine-Tryptophan-Ketoglutarate cardioplegia was used until December 2021, del Nido cardioplegia was given in all the cases thereafter. The left atrium was opened using a left atrial atriotomy in the inter-atrial groove. The mitral valve apparatus was exposed on direct vision with the aid of an atrial retractor, no video assistance tool was used. Video supports are available at <https://www.minicardiacsurgery-univpm-research.com/video-gallery/>. Several repair techniques, such as leaflet resection, implantation of artificial chords and annuloplasty rings were used. Mitral valve replacement was performed using the common stented biologic or mechanical substitutes anchored with 2/0 non-adsorbable interrupted sutures with pledgets.

164

165 *Statistical analysis*

Continuous variables were expressed as mean (SD) or median with interquartile range (IQR). Categorical variables were expressed as frequencies and percentages. Comparisons of preoperative, intraoperative and postoperative variables were performed between the fast track and non-fast track extubation cohorts using the appropriate test (Student's t-test or Mann-Whitney U test, χ^2 or Fisher's exact test). A logistic regression was performed to study the association between preoperative characteristics (*age, gender, chronic kidney disease (eGFR<50 mL/min/1.73m²), NYHA III/IV, LVEF (%), systolic pulmonary artery pressure (>30 mmHg), isolated mitral surgery, degenerative mitral valve disease, cardiopulmonary bypass time*, and the likelihood of undergoing fast track extubation. A logistic regression analysis was used to study the association between each of the following outcomes, *ICU length of stay (cut off 1 day), overall postoperative hospital stay (cut off 7 days), discharge home, discharge home within postoperative day 7*, and fast track extubation, by including

176 in the multivariable model the following variables that were judged as potential confounders, *age (years)*,
177 *gender, chronic kidney disease (eGFR<50 mL/min/1.73m²), NYHA III/IV, LVEF (%), systolic pulmonary artery*
178 *pressure (>30 mmHg), isolated mitral surgery, degenerative mitral valve disease, cardiopulmonary bypass*
179 *time*. A specular analysis was conducted in patients in the fast track group by considering the two subgroups
180 On table extubation and Extubation≤6 hours in ICU.

181 A p-value of ≤0.05 was considered statistically significant. The analysis was generated using Statistical
182 Analysis Software (SAS), Version 3.8, SAS University Edition (SAS Institute Inc., Cary, NC). Figure 1 outlines the
183 design of the study.

184

185 **Results**

186 During the study period 356 patients were scheduled for minimally invasive mitral valve surgery following
187 the ultra-fast track protocol and represented the subjects of this study. The preoperative characteristics of
188 the overall population who underwent trans-axillary mitral valve surgery are summarised in Supplemental
189 Table 2. Mitral valve repair was performed in 94% of the patients with degenerative disease. Nineteen
190 patients with degenerative disease had valve replacement – octogenarians with heavy annular calcification
191 (n=8 patients, mean age 83 years old), because of leaflets/chordal calcification (n=3) or diffuse bileaflets
192 degenerative lesions (n=4), unsatisfactory repair result at intraoperative evaluation (n=4). Mean cross-clamp
193 time was 65±23 minutes and mean cardiopulmonary bypass time was 103±33 minutes (Supplemental Table
194 3). 30-day mortality was 0.3% (1 patient who died after multiple complications associated with iatrogenic
195 aortic dissection), postoperative cerebral stroke rate was 0.3%. Supplemental Table 4 provides details
196 regarding postoperative outcomes.

197 Median mechanical ventilation time was 3 [0-6] hours. Four patients experienced major intraoperative
198 complications and they could not be considered for an early extubation (iatrogenic aortic dissection,
199 intraoperative acute myocardial infarction, injury of thyroid cartilage, compromised gas exchange and
200 ventilation). In total 74 patients (21%) were ultimately extubated after 6 hours since the end of the surgical

201 procedure (Non-fast track group). Two hundred eighty two patients (79%) were extubated within 6 hours
202 since the end of the operation (Fast track group). One hundred sixty patients (45%) were extubated in theatre
203 immediately after the operation and before the transfer to ICU – On table extubation subgroup – and
204 underwent through the ultra-fast track pathway. Figure 2 provides a graphical illustration of the adoption of
205 fast track and on table extubation throughout the study period. Mean postoperative global hospital stay was
206 7 days with 47% of the patients discharged home without the need for any further period of cardiopulmonary
207 rehabilitation or transfer to medical facilities. Figure 3 provides a graphical illustration of the percentage of
208 patients discharged home throughout the study period.

209

210 *Fast track vs non-fast track*

211 There was no difference in preoperative characteristics between fast track (n=282) and non-fast track (n=74)
212 patients (Table 1, Supplemental Figure 1 panel A). None of the preoperative variables was associated with
213 the likelihood of undergoing fast track extubation. Among operative factors, a shorter CPB time was
214 independently associated with fast track extubation (Supplemental table 5). No difference was found
215 between the two groups in terms of 30-day mortality, postoperative cerebral stroke, reintubation for
216 respiratory failure, occurrence of postoperative atrial fibrillation.

217 ICU ($p<0.001$) and hospital stays ($p=0.005$) were shorter in fast track group, furthermore these patients had
218 a higher rate of discharge home (52% vs 26% in non-fast track; $p<0.001$) (Table 2). Multivariable analysis
219 results are summarised in Table 5 and showed that fast track extubation was associated with ICU stay $\leq$ 1 day,
220 discharge home and discharge home within postoperative day 7. This analysis was carried out excluding the
221 4 patients who had major intraoperative complications since they were not considered for an early
222 extubation and for whom a longer period of mechanical ventilation and ICU stay was expected.

223 We carried out a further analysis comparing fast track patients with non-fast track patients who had a fully
224 straightforward early postoperative course (n=52). The twenty-two patients who were excluded from this
225 analysis comprised the 4 patients with intraoperative complications and further 18 patients who, in the early

226 postoperative hours, experienced events that might have impacted the length of intubation and their stay in
227 the Intensive Care Unit [agitation (n=6), seizure (n=1), signs of myocardial ischaemia (n=3), bleeding (n=6),
228 cervicolateral haematoma (n=1), accidental removal of chest drainage (n=1)]. We found that fast track
229 extubation was associated with ICU stay ≤ 1 day (OR 3.54, 95% CI 1.67-7.50, $p=0.001$).

230 Patients who underwent fast track extubation had a lower rate of reopening for bleeding ($p<0.001$). This
231 finding was confirmed by multivariable analysis, including age, gender, etiology, chronic kidney disease,
232 NYHA class, isolated mitral surgery, LVEF, CPB time (OR 0.168, 95% CI 0.047-0.602; $p=0.006$). Similarly,
233 patients who had fast track extubation had a lower rate of transfusion ($p=0.002$) as confirmed after the
234 exclusion of patients who experienced early reoperation for bleeding (OR 0.473, 95% CI 0.232-0.967;
235 $p=0.040$).

236

237 *On table extubation vs Extubation ≤ 6 hours in ICU*

238 One hundred sixty patients were extubated on table (*On table extubation* subgroup). Compared with patients
239 extubated in ICU within 6 hours ($n=122$, *Extubation ≤ 6 hours in ICU* subgroup), these patients were younger
240 and had a higher mean LVEF (Table 3, Supplemental Figure 1 panel B). Younger age ($p=0.047$) was
241 independently associated with the likelihood of undergoing on table extubation (Supplemental Table 6).
242 There was no difference between these two subgroups in terms of 30-day mortality and postoperative
243 complications. The median mechanical ventilation time in patients extubated after the transfer to ICU was 4
244 [3-5] hours. Patients extubated in theatre experienced a shorter stay in ICU ($p=0.007$) and were more
245 frequently discharged home with no need of any further period of rehabilitation ($p=0.002$). Multivariable
246 analysis results are summarised in Table 5 and showed that extubation on table was associated with ICU
247 length of stay ≤ 1 day and higher rate of discharge home and discharge home within postoperative day 7.

248

249

250 **Comment**

251 Minimal access surgery is an established, yet diverse, approach for mitral valve surgery which provides
252 excellent results and brings lower postoperative morbidity (21-24). Regardless of the choice of surgical access
253 and its inherent techniques – anterior/lateral/trans-axillary mini-thoracotomy, endoscopic, thoracoscopic,
254 robotic – a minimally invasive approach should go far beyond the goal of a small incision.

255 The concept of pursuing an early extubation is not new in cardiac surgery as several studies have already
256 underscored the benefits associated with a fast track extubation especially in OPCABG and CABG operations,
257 mini heart valve surgery and transapical TAVI (4-8,25,26). However, only in recent years, a series of evidence-
258 based perioperative care pathways have been embedded into cardiac surgery practice with the aim of
259 reducing the physiological and psychological trauma and achieving a quick recovery (10-13). These
260 experiences yet included mixed types of surgical operations with few mitral valve cases.

261 Our study was entirely focused on patients operated on for mitral valve disease. The first noteworthy finding
262 was that following trans-axillary surgery with ultra-fast track anaesthetic, perfusion and pain management,
263 almost 80% of our mitral patients were extubated within 6 hours after the end of surgical procedures and on
264 table extubation soon after the completion of surgery was achieved in almost 45% of the cases. Our data
265 showed that early extubation (≤ 6 hours) was safe with $<1\%$ of the patients requiring reintubation for
266 respiratory failure. We found no difference in the usual hard endpoints including 30-day mortality and
267 perioperative cerebral stroke between patients who had fast track and non-fast track extubation.
268 Nevertheless, the former experienced shorter ICU stay and hospitalization as shown by the multivariable
269 analysis including several potential confounders. These data were also confirmed by a sub-analysis
270 comparing non-fast track patients who had a straightforward early postoperative course (median mechanical
271 ventilation time 10 hours) with fast track patients (median mechanical ventilation time 4 hours). A delayed
272 extubation was again associated with a lower probability of day 1 ICU discharge. These data are difficult to
273 compare due to paucity of similar experiences in mitral surgery. A recent analysis from the German Heart
274 Center team in Berlin (8) based on mitral patients treated with a video-assisted thoracoscopic approach for

275 degenerative disease reported a successful fast track course (<10 hours extubation, <1 day ICU stay, no ICU
276 readmission) in more than half of the cases with a mean postoperative hospital stay of 6 days and no
277 mortality.

278 In our experience, none of the preoperative factors was associated with the likelihood of undergoing fast
279 track extubation. Conversely, as already highlighted in literature (8,27), longer CPB time turned to be
280 associated with non-fast track extubation. This finding further underlines the importance of aiming for a
281 limited biological trauma together with a reduced incisional trauma. Our direct vision minimally invasive
282 approach was characterised by operative times (mean CPB time 104 minutes, mean cross-clamp time 65
283 minutes) well below those normally described in mini-thoracotomy surgery (21,22,24), and this probably has
284 favoured the pursuit of a fast track pathway in almost 80% of the cases.

285 Surgery – although transiently – can represent the most traumatic and disabling event for paucisymptomatic
286 and relatively young patients and can severely affect the functional status of frail and comorbid patients. The
287 spread of transcatheter therapies highlighted that patients' expectations are far beyond the mere technical
288 result and focus on a fast recovery with rapid return to pre-operative lifestyle with less physical and
289 emotional stress. Having achieved a high safety profile with a rate of mortality and cerebral stroke less than
290 0.5%, every effort should be made to reduce the impact of collateral discomfort and damages associated
291 with the whole surgical and perioperative care in order to improve the patient's experience throughout the
292 hospitalization process. Contemporary surgical techniques associated with ERAS evidence-based protocol
293 can successfully meet these requests while guaranteeing satisfactory and durable results (9-13,15).

294 The first goal of our ultra-fast track protocol was the extubation in theatre soon after the end of the
295 procedure. In the past, concerns were raised about the safety of on table extubation after cardiac surgery
296 and its alleged advantage over an early ICU extubation (28). More recent experiences based on mixed cardiac
297 surgery populations showed that on table extubation was safe (29,30), and our data confirmed these findings
298 as we achieved extubation in theatre in about 45% of the patients – more than 50% in the last 2 years – with
299 no increased risk of reintubation for respiratory failure. We have derived from our data a calculator of the

300 probability of successfully undergoing on table extubation after minimally invasive mitral valve surgery. This
301 calculator, which was based on univariable and multivariable logistic regression analyses including patients'
302 preoperative and operative factors such as age, CPB time, PAPs, NYHA, gender, mitral regurgitation etiology,
303 type of mitral valve procedure (repair or replacement), renal function (eGFR<50 mL/min/1.73m²), LVEF,
304 combined procedures, is available with all the relevant information in the Supplemental materials.

305 We found that patients who successfully entered the ultra-fast track pathway including on table extubation
306 day 0 mobilization and physiotherapy, immediate contact with relatives, earlier feeding, experienced
307 substantial advantages over ICU extubation≤6 hours in terms of higher rates of day 1 discharge from ICU,
308 discharge home and discharge home within 7 days. Alongside the achievement of these results, we expect
309 that this practice has the potential to improve the overall patients' and families' experience associated with
310 the surgical care. A thorough investigation based on patient reported outcomes could further strengthen the
311 value and the importance of providing a person-centred treatment taking into account not only the technical
312 result but also addressing the request for a prompt functional recovery.

313 Indeed the patients included in our study represent a low-risk and selected population and the generalization
314 of these results in high risk and unstable patients is not obvious. Nevertheless, as learnt from high risk and
315 frail patients undergoing minimalistic intervention, the combination of reduced tissue trauma, short
316 operative times, early extubation and mobilization, are expected to have a favourable impact on the
317 postoperative course of more complex and comorbid patients who could certainly benefit from an
318 established and shared institutional ERAS program.

319 Within these limitations, we found that fast track extubation was achievable in most of the patients
320 undergoing trans-axillary minimally invasive mitral valve surgery and was associated with higher rates of day
321 1 ICU discharge and home discharge, reduced bleeding and transfusion rates. On table extubation was
322 associated with further reduced ICU stay and hospitalization.

323

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326 **Data availability statement:** The data underlying this article will be shared on reasonable request to the
327 corresponding author

328

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413 **Tables**

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Table 1. Preoperative and intraoperative data of patients who underwent fast track (extubation within 6 hours) and non-fast track extubation (extubation time>6 hours).

Variables	Fast track N=282	Non-fast track N=74	p	[SMD]
	Mean (SD)	Mean (SD)		
	n (%)	n (%)		
Age (years)	63 (12)	64 (11)	0.22	0.03
Gender (M/F)	176/106	40/34	0.19	0.16
BMI (kg/m ²)	24.9 (4.2)	24.7 (4.5)	0.53	0.05
COPD	7 (2)	4 (5)	0.36	0.16
CKD (eGFR<50 mL/min/1.73m ²)	37 (13)	8 (10)	0.59	0.09
NYHA class≥III	88 (31)	26 (34)	0.52	0.06
History of AF	70 (25)	21 (28)	0.53	0.07
LVEF (%)	61 (7)	60 (8)	0.33	0.14
Mitral regurgitation	269 (95)	68 (92)	0.23	0.12
Degenerative MR	250 (89)	63 (85)	0.40	0.14
PAPs≥30 mmHg	100 (35)	32 (43)	0.21	0.16
Tricuspid regurgitation ≥ moderate	68 (24)	15 (20)	0.49	0.10
EuroSCORE II (%)	1.2 (1.0)	1.2 (0.8)	0.13	0
Isolated MV surgery	239 (85)	66 (89)	0.33	0.12
Mitral valve repair for MR	250/269 (93)	57/68 (84)	0.018	0.28
Mitral repair for degenerative MR	236/250 (95)	55/63 (90)	0.006	0.32
CPB time (minutes)	100 (26)	119 (44)	<0.001	0.62
Cross-clamp time (minutes)	62 (20)	75 (30)	<0.001	0.58

446 AF, atrial fibrillation; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; LVEF, left
447 ventricle ejection fraction; MR, mitral regurgitation; MV, mitral valve; PAPs, systolic pulmonary artery
448 pressure
449

450 **Table 2.** Postoperative data of patients who underwent fast track (extubation within 6 hours) and non-fast
451 track extubation (extubation time>6 hours).

Variables	Fast track N=282	Non-fast track N=74	p
	Mean (SD) or median [IQR1-IQR3] n (%)	Mean (SD) or median [IQR1-IQR3] n (%)	
Mechanical ventilation time (hours)	0 [0-4]	10 [8-18]	<0.001
Reintubation for respiratory failure	2 (0.7)	3 (4)	0.10
Bleeding re-thoracotomy	6 (2)	9 (12)	<0.001
Cerebral stroke	1 (0.4)	0	0.99
Delirium	13 (5)	5 (7)	0.45
New onset AF (in preoperative SR)	51/212 (24)	12/52 (23)	0.88
ICU stay (hours)	23 [18-28]	40 [24-66]	<0.001
Pre-discharge red blood cells transfusion (number of patients)	49 (17)	25 (34)	0.002
30-day mortality	0	1 (1.3%)	0.47
Hospital stay (days)	7 (4)	9 (5)	0.005
Discharge Home	148 (52)	19 (26)	<0.001

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455 **Table 3.** Preoperative and intraoperative data of patients who underwent on table extubation and ICU
456 extubation within 6 hours.

Variables	On table extubation N=160	Extubation≤6 hours in ICU N=122	p	[SMD]
	Mean (SD)	Mean (SD)		
	n (%)	n (%)		
Age (years)	61 (11)	64 (12)	0.019	0.26
Gender (M/F)	105/55	71/51	0.20	0.17
BMI (kg/m ²)	24.9 (4.2)	24.8 (4.2)	0.90	0.02
COPD	6 (4)	1 (1)	0.23	0.16
CKD (eGFR<50 mL/min/1.73m ²)	16 (10)	21 (17)	0.07	0.21
NYHA class≥III	52 (32)	36 (30)	0.59	0.04
History of AF	35 (22)	35 (29)	0.19	0.16
LVEF (%)	62 (6)	60 (8)	0.05	0.29
Mitral regurgitation	154 (96)	115 (96)	0.43	0
Degenerative MR	149 (93)	101 (84)	0.006	0.28
PAPs≥30 mmHg	58 (36)	42 (34)	0.75	0.04
Tricuspid regurgitation ≥ moderate	39 (24)	29 (24)	0.91	0
EuroSCORE II (%)	1.1 (1.0)	1.3 (1.0)	0.08	0.20
Isolated MV surgery	137 (86)	102 (85)	0.88	0.03

MV repair for MR	149/154 (97)	101/115 (88)	0.005	0.35
Mitral repair for degenerative MR	145/148 (98)	91/102 (90)	0.015	0.34
CPB time (minutes)	98 (25)	103 (28)	0.06	0.19
Cross-clamp time (minutes)	62 (17)	63 (22)	0.69	0.05

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458 AF, atrial fibrillation; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; LVEF, left
459 ventricle ejection fraction; MR, mitral regurgitation; MV, mitral valve; PAPs, systolic pulmonary artery
460 pressure

461

462 **Table 4.** Postoperative data of patients who underwent on table extubation and ICU extubation within 6
463 hours.

Variables	On table extubation N=160	Extubation≤6 hours in ICU N=122	p
	Mean (SD) or median [IQR1- IQR3] n (%)	Mean (SD) or median [IQR1-IQR3] n (%)	
Mechanical ventilation time (hours)	0	4 [3-5]	-
Reintubation for respiratory failure	0	2 (2)	0.36
Bleeding re-thoracotomy	2 (1)	4 (3)	0.45
Cerebral stroke	0	1 (0.8)	0.89
Delirium	4 (3)	9 (7)	0.10
New onset AF (in preoperative SR)	27/123 (22)	24/87 (28)	0.34
ICU stay (hours)	23 [16-25]	24 [21-35]	0.007
Pre-discharge red blood cells transfusion (number of patients)	26 (16)	23 (19)	0.57
30-day mortality	0	0	-
Hospital stay (days)	7 (4)	8 (4)	0.19
Discharge Home	97 (61)	51 (42)	0.002

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467 **Table 5.** Multivariable analysis results about the association of fast track and on table extubation
 468 management with postoperative stay endpoints.

Endpoints	Fast track vs Non-fast track*		On table extubation vs Extubation≤6 hours in ICU	
	OR [95% CI]	p	OR [95% CI]	p
ICU stay≤1 day	4.67 [2.52-8.69]	<0.001	2.33 [1.21-4.49]	0.011
Hospital stay≤7 days	1.74 [0.96-3.15]	0.07	1.21 [0.69-2.11]	0.49
Discharge home	2.17 [1.13-4.17]	0.020	1.75 [1.02-3.03]	0.043
Discharge home within 7 days	2.22 [1.07-4.64]	0.033	2.20 [1.24-3.91]	0.007

469 *Four patients in the non-fast track group were excluded from this analysis due to major intraoperative
 470 complications (iatrogenic aortic dissection, intraoperative acute myocardial infarction, injury of thyroid
 471 cartilage, compromised gas exchange and ventilation)

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Figures

Central Image. (self explanatory)

Figure 1. Design of the study.

Figure 2. Percentage of patients who underwent fast track extubation (FT, $p=0.59$) and on table extubation (OT, $p=0.035$) in each year of the study period.

Figure 3. Percentage of patients who were discharged home with no need of any further period of cardiopulmonary rehabilitation or transfer to medical facilities in each year of the study period ($p=0.002$).

Figure 2

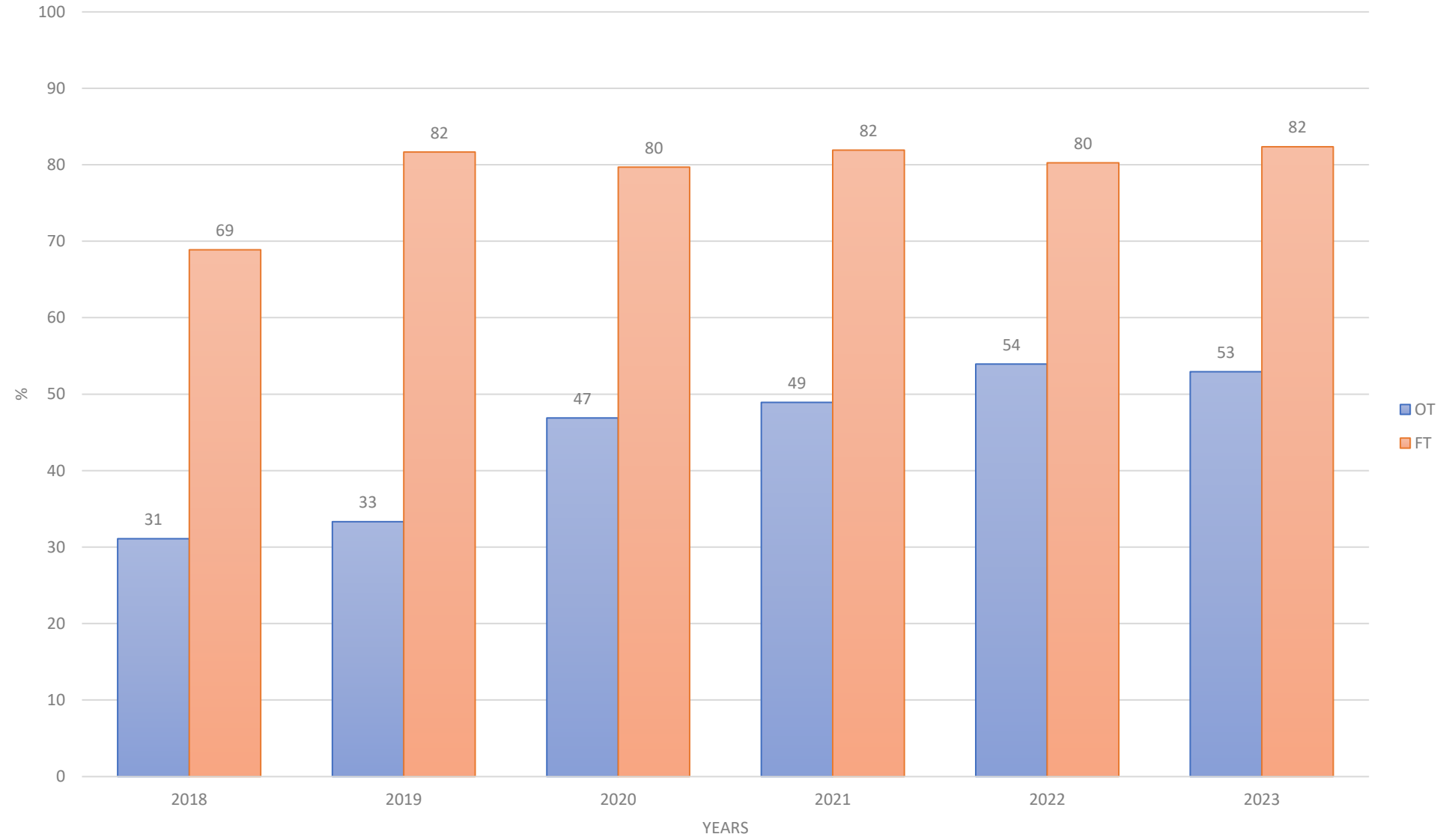


Figure 3

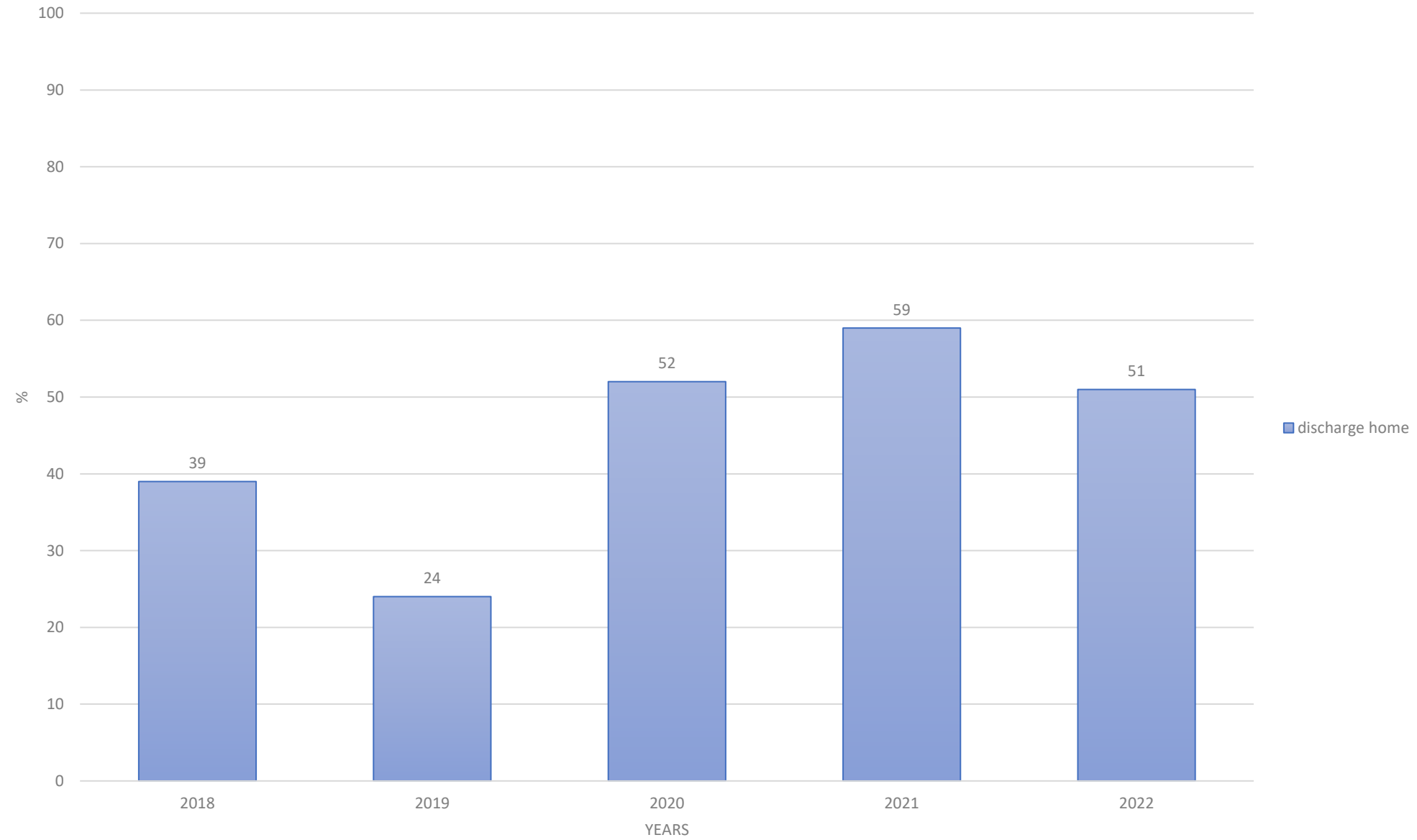
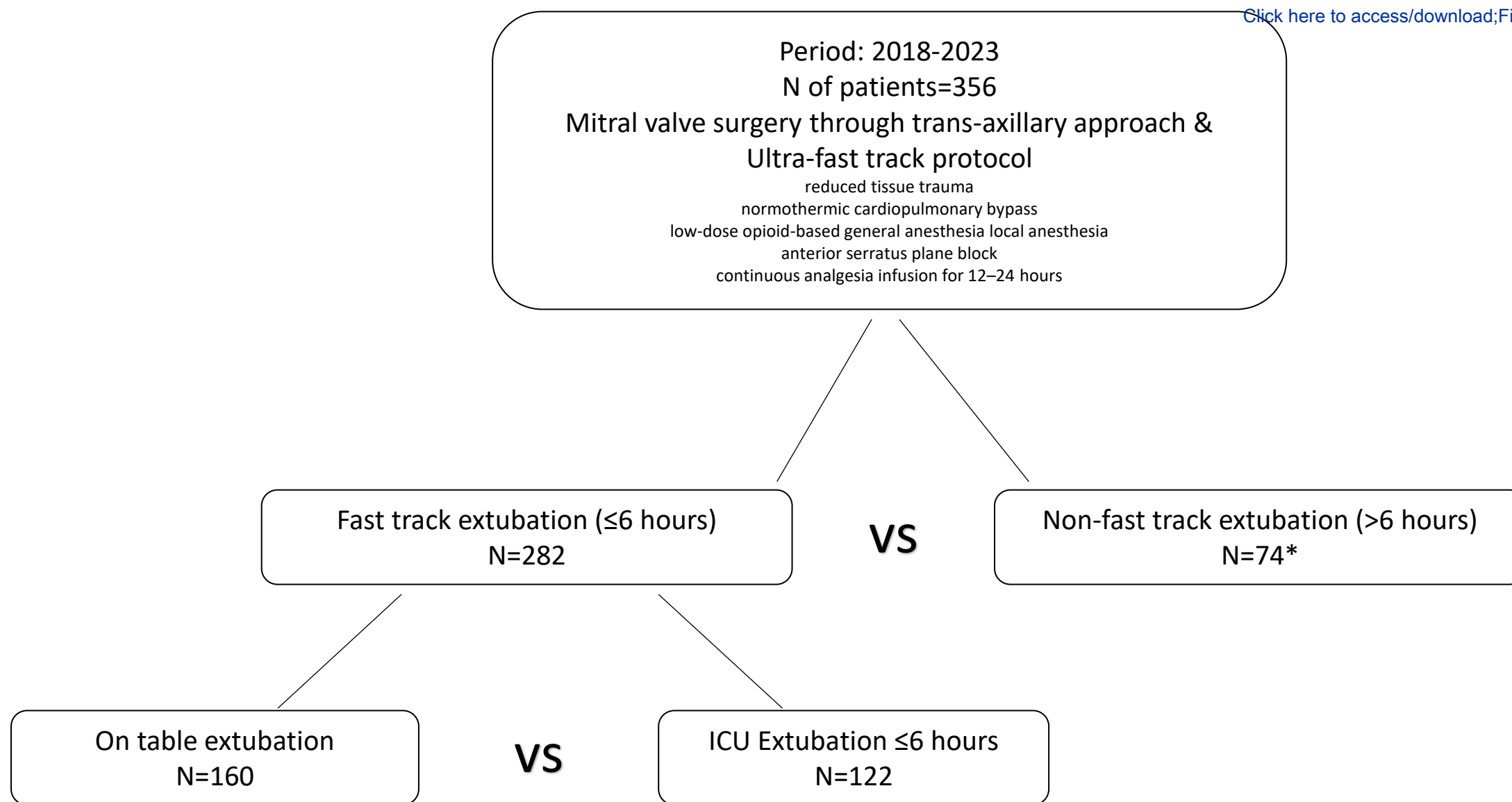


Figure 1

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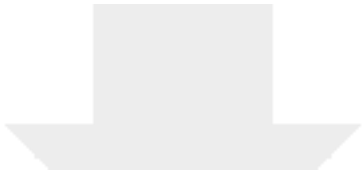
vs

Logreg association between preoperative and operative variables and extubation management

Logreg association between extubation management and ICU stay, hospital length of stay, discharge destination

*two analyses were performed excluding 4 patients who had intraoperative major complications and further 18 patients with early complications after ICU admission





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Supplementary material
suppl figure 1.pdf

