# RESEARCH



# Elevated right ventricular systolic pressure and outcomes after emergency hip surgery: a case control study



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# Abstract

Patients at risk of pulmonary hypertension frequently present for emergency orthopedic surgery. A right ventricular systolic pressure of 35 mmHg or above, calculated from a tricuspid regurgitant jet on transthoracic echocardiogram, is considered an appropriate screening test for pulmonary hypertension. The aim of this study was to evaluate the impact of an elevated right ventricular systolic pressure detected on a preoperative transthoracic echocardiogram, on outcomes after emergency hip surgery. We undertook a retrospective, single centre, case control study of 98 adult patients who had a transthoracic echocardiogram before undergoing emergency hip surgery over a six-year period. Forty-two of the 98 patients (43%) had an elevated right ventricular systolic pressure ( $\geq$  35mmHg) and 56 patients (57%) had a normal right ventricular systolic pressure (< 35mmHg) on preoperative echocardiography. All in-hospital deaths in our study occurred in the elevated right ventricular systolic pressure group (8/42 (19%) vs. 0/56 (0%), p = < 0.001). Three patients died within one week of surgery after a cardiac arrest. The remaining 5 patients died a median of 26 (IQR 24–59) days after surgery due to pneumonia and progression of comorbid disease. Patients with an elevated right ventricular systolic pressure were older and had a higher prevalence of atrial fibrillation. In multiple logistic regression analysis, there was no association between either of these variables and survival to hospital discharge. There was a greater number of patients with heart failure, ischaemic heart disease and chronic obstructive pulmonary disease in the elevated right ventricular systolic pressure group, however the differences between the two groups did not reach statistical significance. This study highlights an association between elevated preoperative right ventricular systolic pressure and increased mortality after emergency hip surgery. Elevated right ventricular systolic pressure could be indicative of pulmonary hypertension or be secondary to underlying heart or lung disease. Irrespective of the exact cause of raised right ventricular systolic pressure, the association with increased in hospital mortality warrants further investigation.

Keywords Right ventricular systolic pressure, Emergency hip surgery, Outcomes

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# Background

Pulmonary hypertension (PH), a syndrome characterised by increased right ventricular (RV) afterload and subsequent RV dysfunction, is estimated to affect approximately 1% of the global population [1]. In an attempt to promote earlier detection, the 6th World Symposium on Pulmonary Hypertension reduced the mean pulmonary artery pressure (mPAP) threshold for the diagnosis of PH from 25mmHg to 20mmHg at rest, on right heart catheterization (RHC) [2]. Mortality was found to be increased in patients with a mPAP > 19mmHg and a pulmonary vascular resistance of > 2 Wood units [3].

Patients at risk of PH often present for emergency surgery in a hospital which is not a recognized PH centre. There may be insufficient time and limited access to advanced hemodynamic testing to establish a definitive diagnosis of PH. Anesthesia and surgery in patients with PH have an attendant risk of perioperative morbidity and mortality [4]. The rate of major adverse cardiovascular events, including death was 8.3% in PH patients compared to 2% in non-PH patients after major noncardiac surgery [5]. The mortality rate was increased to 15–50% for PH patients undergoing emergency surgery [6]. Orthopedic procedures associated with perioperative bone marrow or cement embolization to the pulmonary circulation can also lead to acute RV failure and death [7].

A joint task force of the European Society of Cardiology and European Respiratory Society proposed that a peak velocity of tricuspid regurgitation of greater than 2.8 m/s on continuous wave doppler on transthoracic echocardiography (TTE), which corresponds to a right ventricular systolic pressure (RVSP) of approximately 35mmHg, can be used as a screening test for PH. A subsequent RHC is required to establish a definitive diagnosis of PH [1]. In patients presenting for emergency hip fracture fixation or joint replacement surgery, a preoperative elevation in RVSP may be due to undiagnosed PH, underlying chronic cardiopulmonary disease or an acute clinical deterioration, such as pneumonia or pulmonary oedema.

The primary aim of this study was to compare the perioperative course and outcomes in patients with a preoperative RVSP of  $\geq$  35 mmHg (referred to in this study as elevated RVSP) to those with a preoperative RVSP of < 35 mmHg (referred to in this study as normal RVSP), following emergency hip fracture fixation or joint replacement surgery.

### Methods

A retrospective, observational, case control study in a 719 bed, university-affiliated, adult teaching hospital was undertaken. The national PH service, the national Heart and Lung Transplantation service, the regional Major Trauma service and the national Extracorporeal Membrane Oxygenation service are based in our hospital. The study was approved by the Department of Anesthesiology Audit Committee, a subgroup of the Mater Hospital Audit Committee, under The National Quality Improvement Directorate.

The patients included in this study were those presenting for emergency hip fracture fixation or joint replacement over a six-year period from 30th September 2015 to 30th November 2021.

Data collected included patient demographics, functional status, past medical history and TTE results. Emergency hip surgery patients included in this study had a preoperative TTE performed by British Society of Echocardiography accredited echo-physiologists and all available data from the TTE reports in their medical records was collected. Measurements of RVSP and other echocardiographic features of PH were used to identify patients with potentially undiagnosed PH [1]. When right atrial pressure (RAP) was recorded in the TTE report, this figure was included in the calculation of RVSP. Where no RAP was given, an estimated RAP of 5 mmHg was used in the RVSP calculation. We noted the mode of anesthesia, whether invasive arterial blood pressure monitoring and central venous catheterization were utilised. The number of patients with hemodynamic instability (defined as one or more episodes when recorded mean arterial pressure was greater than 150 mmHg or less than 50mmHg) in the intra- and postoperative period was noted. We recorded if the patient required admission to a Critical Care bed postoperatively, their critical care and hospital length of stay and their survival to hospital discharge.

Data was collected over a 6-month period (January to July 2023) in The Mater Hospital, Dublin. Patient details were acquired from retrospective chart reviews, IntelliSpace Critical Care, Anesthesia software (Philips)<sup>®</sup> and Centricity Software (GE HealthCare)® and transferred onto a secure, password protected Microsoft Excel spreadsheet. The Shapiro-Wilk test was used to test for normality of distribution. Non-parametric data were analysed using the Mann Whitney U test and categorical variables were compared using the Chi square test. Multiple logistic regression analysis was used to evaluate the association between elevated preoperative RVSP and in-hospital mortality while adjusting for potential confounders. A two-tailed p value of less than 0.05 was set to indicate statistical significance for each test. Statistical analysis was performed using MedCalc software (Belgium)<sup>®</sup>, GraphPad Prism version 10.0.0 for Windows (USA)° and Stata software (USA) °.

# Results

During the study period, 527 patients underwent emergency hip surgery for joint replacement or fracture fixation in our hospital. Ninety-eight patients (19%) had a preoperative TTE and were included in the study population (Fig. 1).

The indications for requesting a preoperative TTE included a history or signs of heart disease (n=88), a history of stroke or thromboembolic event (n=5) or a



Fig. 1 Study population

TTE: transthoracic echocardiogram; RVSP: right ventricular systolic pressure; normal RVSP: RVSP < 35 mmHg

history of pulmonary hypertension (n = 4). The indications for preoperative TTE in the remaining patient were not recorded.

Forty-two of the 98 patients (43%) who had a preoperative TTE were found to have an elevated RVSP (mean RVSP:  $47 \pm 10$ mmHg). In these 42 patients, the RVSP was 35–39 mmHg in 9 patients, 40-49mmHg in 18 patients and  $\geq$  50 mmHg in 15 patients. Fifty-six patients (57%) were classified as having a normal RVSP (mean RVSP:  $25 \pm 6$ mmHg). Of these 56 patients, 22 had no recorded RVSP on their preoperative TTE due to insufficient tricuspid regurgitation or poorly visualised tricuspid valve. For the purposes of this study, these 22 patients were assigned to the normal RVSP group.

Four of the 98 patients (4%) had a previous diagnosis of pulmonary hypertension. All were found to have an

	Elevated	Normal	Р
	RVSP	RVSP	value
	n=42	n=56	
Baseline characteristics			
Age, years, median, (IQR)	83 (75,89)	77 (68,85)	0.040
Male, no. (%)	14 (33%)	26 (46%)	0.196
ASA status			
ASA class 4, no. (%)	11 (26%)	10 (18%)	0.342
Comorbidities			
Cardiac disease			
Heart failure, no. (%)	11 (26%)	7 (12%)	0.075
lschemic heart disease, no (%)	17 (40%)	15 (27%)	0.176
Valve replacement, no. (%)	3 (7%)	4 (7%)	1.000
Atrial fibrillation, no. (%)	19 (45%)	12 (21%)	0.011
Pulmonary hypertension, no. (%)	4 (9%)	0 (0%)	0.022
Respiratory disease			
COPD, no. (%)	13 (30%)	8 (14%)	0.054
Smoking, no. (%)	6 (14%)	7 (12%)	0.770
Obstructive sleep apnea, no. (%)	2 (5%)	2 (3%)	0.612
Asthma, no. (%)	3 (7%)	3 (5%)	0.678
Bronchiectasis, no. (%)	2 (5%)	0 (0%)	0.092
Vascular disease			
Hypertension, no. (%)	20 (48%)	27 (48%)	1.000
Cerebrovascular disease / Transient	7 (17%)	12 (21%)	0.621
ischemic attack, mo. (%)			
Peripheral vascular disease / venous	1 (2%)	7 (12%)	0.067
ulcers, no. (%)			
Abdominal aortic aneurysm, no. (%)	3 (7%)	3 (5%)	0.678
Thromboembolic disease			
Deep vein thrombosis / pulmonary	4 (9%)	5 (9%)	1.000
embolism, no. (%)			
Renal disease			
Chronic kidney disease, no. (%)	9 (21%)	8 (14%)	0.363
Dialysis dependence, no. (%)	1 (2%)	2 (4%)	0.576

RVSP: right ventricular systolic pressure; ASA: American Society of Anesthesiology; COPD: Chronic obstructive pulmonary disease; IQR: interguartile range elevated RVSP (mean  $47 \pm 6$ mmHg) on TTE. One had PH secondary to left heart disease and three had multifactorial mechanisms.

During the study period, the mortality rate for all patients undergoing emergency hip surgery (n = 527) was 5% and the mortality rate for patients who did not have a preoperative TTE (n = 429) was 4%. There were no in-hospital deaths in the normal RVSP (n = 56) group, whereas, patients found to have an elevated RVSP (n = 42) on preoperative TTE had a 19% mortality rate.

In bivariate analysis, patients with an elevated RVSP were older (83 vs. 77 years) but the number of patients with an American Society of Anesthesiology (ASA) class of 4 or above in both groups were similar (26% vs. 18%) (Table 1). The number of patients with atrial fibrillation was significantly higher in the elevated RVSP group (Table 1). The number of patients with heart failure, ischemic heart disease or chronic obstructive pulmonary disease (COPD) was higher in the elevated RVSP group but these differences did not reach statistical significance (Table 1).

As RVSP is calculated from a tricuspid regurgitant jet, tricuspid regurgitation was noted more frequently in patients with an elevated RVSP. Right ventricular dilation (>47 mm in males, or >43 mm in females at the basal one third of the RV) was also noted more frequently in patients with an elevated RVSP [8]. Right ventricular function did not differ significantly between the groups Tricuspid Annular Plane Systolic Excursion or the rate of reduced RV function.

There was no significant difference in left heart function and no significant difference in left-sided valvular pathologies on TTE, between the two groups, (Table 2).

Seventy-four patients (75%) had hip hemiarthroplasty surgery, 23 patients (23%) underwent either total or revision arthroplasty and one patient (1%) had a closed reduction of a fractured femur (Table 3).

The mode of anesthesia, perioperative hemodynamic monitoring, duration of surgery, frequency of perioperative hemodynamic instability and postoperative care destination did not differ significantly between the groups (Table 3). There was no difference in the median time from surgery to hospital discharge in both groups (19 vs. 14 days).

Patients with an elevated RVSP were significantly more likely to die in hospital. All of the in-hospital deaths occurred in the elevated RVSP group (8/42 (19%) vs. 0/56 (0%), p = < 0.001) (Table 3). Of the 8 patients who died in hospital, the median age was 82 years, the average ASA classification was 4 and the mean RVSP was 48 mmHg. One of the patients who died prior to hospital discharge was known to have PH, the remaining 7 patients had no previous diagnosis of PH. Five of the 8 patients who died had general anesthesia, the remaining patients had spinal

Table 2	TTE results: e	levated RVSP	group	versus	normal	RVSP
aroup						

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	Ele- vated RVSP n=42	Nor- mal RVSP n=56	<i>P</i> value
Left ventricular pathology			
Left ventricular dysfunction (EF $\leq$ 40%), no. (%)	3 (7%)	5 (9%)	0.721
Left ventricular hypertrophy, no. (%)	4 (9%)	4 (7%)	0.717
Diastolic dysfunction, no. (%)	3 (7%)	5 (9%)	0.721
Right ventricular pathology			
Right ventricle function reduced, no. (%)	1 (2%)	2 (4%)	0.576
Tricuspid Annular Plane Systolic Excursion, cm (median, IQR)	2 (2,2)	2 (2,3)	0.401
Right ventricular dilation, no. (%)	7 (17%)	1 (2%)	0.008
Valvular pathology			
Moderate to severe left sided valvular pathology (Mitral or aortic valve disease), no. (%)	5 (12%)	5 (9%)	0.630
Moderate to severe tricuspid regurgitation, no. (%) Tricuspid regurgitation, no. (%)	13 (30%)	2 (4%)	< 0.001
Multiple valvular pathologies, no. (%)	4 (9%)	1 (2%)	0.117
Echogenic parameters associated with Pulmonary Hypertension			
RVSP mmHg (mean, standard deviation)	47 ± 10	25 ± 6	< 0.0001
IVC dilated, no. (%)	3 (7%)	1 (2%)	0.221

RVSP: right ventricular systolic pressure; EF: ejection fraction; IVC: inferior vena cava; Right ventricular dilatation: > 47 mm in males, or >43 mm in females at basal one third of the RV [8]; IQR: interquartile range

anesthesia. Five of the patients who died had a central venous catheter placed, required vasopressors and had one or more episodes of hemodynamic instability. All of the patients who died had an arterial line placed perioperatively. Two of the 8 patients who died were admitted to a Critical Care bed postoperatively.

Three patients (including the patient with known PH) died within one week of surgery after a cardiac arrest. The remaining 5 patients died a median of 26 (IQR 24–59) days after surgery due to pneumonia and progression of comorbid disease, often complicated by delirium.

Multiple logistic regression analysis showed that age and atrial fibrillation were not significantly associated with survival to hospital discharge (Table 4).

## Discussion

In our study of elderly patients presenting for emergency hip surgery, an elevated RVSP detected on preoperative TTE was associated with increased in-hospital mortality. Eight patients died before hospital discharge with all of the deaths recorded in the elevated RVSP group and no deaths in the normal RVSP group (8/42 (19%) vs. 0/56 (0%), p = < 0.001). Three patients died within one week of surgery after a cardiac arrest. The remaining 5 patients

Table 3	Perioperative course and outcome: elevated RVSF
group ve	rsus normal RVSP group

<u> </u>	Elevated RVSP n=42	Normal RVSP n=56	<i>P</i> value
Surgery			
Duration of surgery: minutes, (me- dian, IQR)	90 (60,115)	90 (60,120)	0.073
Hemiarthroplasty of femur, no. (%)	37 (88%)	37 (66%)	0.012
Total or revision arthroplasty, no. (%)	4 (9%)	19 (34%)	0.003
Closed reduction of fractured femur, no (%)	1 (2%)	0 (0%)	0.290
Anesthesia			
Spinal anesthesia, no. (%)	23 (54%)	31 (55%)	0.922
General anesthesia, no. (%)	19 (45%)	25 (45%)	1.000
Arterial line inserted, no. (%)	29 (67%)	34 (60%)	0.479
Central venous catheter inserted, no. (%)	10 (24%)	10 (18%)	0.469
Vasopressor infusion via CVC, no. (%)	6 (14%)	6 (11%)	0.656
Hemodynamic instability, no. (%)	16 (38%)	14 (25%)	0.169
Outcome			
Admitted to a Critical Care bed, no. (%)	6 (14%)	9 (16%)	0.785
Critical Care LOS, days, (median, IQR)	2 (2,4)	3 (3,4)	0.549
Time from surgery to hospital dis- charge, days (median, IQR)	19 (12, 54)	14 (8, 32)	0.431
Hospital mortality, no. (%)	8 (19%)	0 (0%)	< 0.001
Survival to hospital discharge, no. (%)	34 (81%)	56 (100%)	< 0.001
Time to death after surgery, days, (median IQR)	18 (10,33)	N/A	N/A
Deaths $\leq$ 7 days after surgery, no. (%)	3 (37%)	N/A	N/A
Deaths $\geq$ 8 days after surgery, no. (%)	5 (62%)	N/A	N/A
Cause of death: cardiac arrest, no. (%)	3 (37%)	N/A	N/A
Cause of death: pneumonia ± progres- sion of comorbid conditions, no. (%)	5 (62%)	N/A	N/A

RVSP: right ventricular systolic pressure; CVC: central venous catheter;

Hemodynamic Instability: number of patients with intra- or postoperative mean arterial blood pressure > 150 or <50 mmHg; LOS: length of stay; IQR: interquartile range

Table 4	Multiple logistic regression	of statistically	significant
factors o	utlined in Table 1		

Survival to Hospital Discharge	Odds Ratios Estimate	95% Con- fidence Interval
Age	0.9705	0.8966 to 1.031
Atrial Fibrillation	0.6333	0.1314 to 3.428

died a median of 26 days after surgery due to pneumonia and progression of comorbid disease, often complicated by delirium. These findings suggest that identifying elevated RVSP preoperatively could provide more accurate risk assessment with allocation of appropriate perioperative resources and follow-up for these patients.

In a study of 25 patients with a definitive diagnosis of PH who underwent elective hip or knee replacement

surgery in a recognized PH centre, no perioperative deaths were recorded, however 11 patients (44%) experienced a significant complication, including hypotension requiring vasopressors, blood transfusion and nonorthopedic infection. The authors concluded that with careful patient selection and optimal perioperative care, satisfactory outcomes can be achieved [9]. In a similar study of 16 patients with severe PH undergoing major orthopedic surgery, one patient (6%) died due to pneumonia and 6 patients (37%) had significant postoperative complications including bleeding, dysrhythmia and poor wound healing [10].

Patients in the above two studies had a definitive diagnosis of PH, with many already stabilised on PH therapy and were undergoing elective procedures in an established PH centre. Under these circumstances, a comprehensive preoperative assessment by a multidisciplinary team could formulate an individualized perioperative care plan. Recent reviews on the perioperative management of patients with an established diagnosis of PH highlight the appropriate adjustment of pulmonary vasodilator therapy, optimization of the primary underlying conditions and identifying patients who should have their surgery undertaken in an expert PH centre [4, 6]. In contrast, all of the patients in our study were undergoing emergency hip surgery with only 4 of 98 patients (4%) having a definitive diagnosis of PH. Current guidelines for the management of patients with hip fractures recommend surgery within 36 h of the fracture, limiting the time available for preoperative optimization [4, 11]. There is a paucity of published evidence on the appropriate management of patients with an elevated RVSP undergoing emergency surgery, but without a formal PH diagnosis.

Transthoracic echocardiography is not routinely indicated in all patients undergoing hip surgery. However, a preoperative echocardiogram should be considered if there is a history of significant cardiac disease or if the patient has new signs or symptoms suggestive of heart failure [12].

A peak velocity of tricuspid regurgitation > 2.8 m/s on TTE (calculated with right atrial pressure), which corresponds to an RVSP of approximately 35mmHg, can be used as a screening tests for to PH [1, 12]. If elevated RVSP is identified or if there are suboptimal windows for estimation of RVSP, additional echocardiographic variables used to clarify the probability of PH should be specifically sought, including interventricular septal flattening, right atrial area, diameter of the pulmonary artery, inferior vena cava diameter and respiratory variation. These variables can then be used to categorise the probability of PH into low, intermediate and high probability [1]. In our study, patients with elevated preoperative RVSP were older and had a higher incidence of atrial fibrillation. However, we found that neither of these variables independently influenced patient survival in our cohort. There was a greater number of patients with heart failure, ischemic heart disease and chronic obstructive pulmonary disease in the elevated RVSP compared to the normal RVSP group, although none of these comorbidities reached statistical significance.

Forty-two of 98 patients (43%) in our study had an elevated RVSP, but only 4 (9%) had a previous diagnosis of PH. The finding of an elevated RVSP could be consistent with undiagnosed PH, or could be secondary to chronic cardiopulmonary disease or an acute decompensation in the patients' health such as with pneumonia or pulmonary oedema. However confirming or grading pulmonary hypertension was beyond the scope of this study as there were no right heart catherization performed, therefore, no mean pulmonary arterial pressures were measured directly. Patients older than 75 years are known to have elevated RVSP [13]. Regardless of the cause of the elevated RVSP in individual patients, the association with increased mortality warrants further investigation. In a recent epidemiological study, patients with a RVSP of 33-39 mmHg were noted to have an increased mortality compared to patients with RVSP < 33 mmHg [14].

A higher proportion of patients in the elevated RVSP group underwent hemiarthroplasty of the hip. Total hip arthroplasty is traditionally associated with a longer duration of surgery when compared to hip hemiarthroplasty, however the duration of surgery was similar in both groups in our study [15].

We found no difference in perioperative management (mode of anesthesia, intraoperative monitoring, incidence of hemodynamic instability or admission to a Critical Care bed) between the two groups of patients. Fifteen percent of the study population were admitted to a Critical Care bed after surgery. In a study from Edinburgh, 2.4% of elderly patients who presented with hip fracture required admission to the Critical Care unit [16].

The time from emergency hip surgery to hospital discharge was prolonged in both groups (19 versus 14 days) reflecting the general frailty and burden of comorbid disease encountered in this cohort of patients. Multiple factors contributed to the delay in discharge including inadequate stepdown and community care [17].

The clinical implications of an elevated RVSP (without a confirmatory RHC) in elderly patients presenting for emergency surgery remains unclear. However, the findings of this study should alert clinicians that patients with a preoperative RVSP > 35mmHg may have an increased risk of in-hospital death. If an elevated preoperative RVSP is detected and additional echocardiographic variables associated with PH (e.g., intraventricular septal flattening, increased right atrial, pulmonary artery or inferior vena cava dimensions) are present, a referral to a PH service for management advice should be considered. If the association between elevated preoperative RVSP and increased mortality is confirmed in other studies, a more focused follow-up of these patients in the postoperative period may be justified.

Our study has several important limitations. Our retrospective observational study, conducted in a single hospital that has a well-established PH service, may have limited generalisability and can only infer association and not causation. As this is a retrospective case control study, the patient cohorts were not perfectly matched and we have attempted to adjust for cofounders with logistic regression analysis. Given the low event rate (hospital deaths), the power in logistic regression analysis estimates is reduced and it is possible that some unmeasured variables could have important implications for patient outcome rather than elevated RVSP alone. In our study, requesting a preoperative TTE in individual patients presenting for emergency hip surgery is likely to have selected out patients considered to be at high risk of adverse perioperative events. Our elevated RVSP patient cohort had some of the echocardiographic features of PH, however without RHC data, no definitive diagnosis of PH can be made. The preoperative TTE's performed on our patients were not focused right-heart studies and additional features used to refine the echogenic probability of PH were not consistently included in the TTE reports. Other than documenting hospital length of stay and mortality, our study did not include ward-based follow-up of our patients.

# Conclusion

In conclusion, 42 of 98 (43%) patients presenting for emergency hip surgery were noted to have an elevated RVSP on preoperative TTE. One in five of these patients did not survive to hospital discharge with all of the inhospital deaths in our study occurring within the elevated RVSP group. Three patients died within one week of surgery after a cardiac arrest. The remainder of the deaths occurred a median of 26 days after surgery and were due to pneumonia and progression of comorbid disease. Patients with elevated RVSP were older with a higher incidence of atrial fibrillation. On multiple logistic regression analysis there was no significant association between these variables and survival to hospital discharge.

A future prospective study comparing the perioperative course and outcome of patients with elevated or normal preoperative RVSP, who are well matched for age and comorbid conditions, would be useful for further defining the relationship between elevated RVSP and increased mortality. If this association is confirmed in other studies, a more focused follow-up of these patients in the postoperative period may be justified.

#### Abbreviations

- ΡH Pulmonary Hypertension RVSP
- Right ventricular systolic pressure Transthoracic echocardiogram TTF
- RV Right ventricular
- mPAP Mean pulmonary artery pressure
- RHC Right heart catheterization
- ASA American Society of Anesthesiology
- COPD Chronic obstructive pulmonary disease
- IOR Interguartile range
- FF Ejection fraction

IVC Inferior vena cava

CVC Central venous catheter

- LOS
- Length of stay

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#### Author contributions

MC: Initial concept of project, data acquisition, data analysis, composition of first and final draft, DOD: data analysis, critical review, final approval of version to be published, BM: critical review, final approval of version to be published, SG: critical review, final approval of the version to be published, AM: concept and study design, critical review, final approval of version to be published.

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#### Data availability

The datasets generated and analysed during the current study is not publicly available as it contains individualised data and deemed likely to compromise anonymity but is available from the corresponding author on reasonable request.

## Declarations

#### Ethics approval and consent to participate

The study received approval from the Mater Hospital Dublin Department of Anesthesia Audit Committee, a subgroup of the Mater Hospital Audit Committee, under The National Quality Improvement Directorate. The approval reference number is CA25-037. Consent to participate was not deemed necessary by the Department of Anesthesia Audit Committee as this was a retrospective study with no direct or indirect patient identifiers.

#### **Consent for publication**

Not applicable.

# **Competing interests**

The authors declare no competing interests.

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