# Does more than a single chest tube for mediastinal drainage affect outcomes after cardiac surgery?

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**Background:** The use of 1 or more mediastinal chest tubes has traditionally been routine for all cardiac surgery procedures to deal with bleeding. However, it remains unproven whether multiple chest tubes offer a benefit over a single chest tube.

**Methods:** All consecutive patients undergoing cardiac surgery (2005–2010) received at least 1 chest tube at the time of surgery based on surgeon preference. Patients were grouped into those receiving a single chest tube (SCT) and those receiving multiple chest tubes (MCT). The primary outcome was return to the operating room for bleeding or tamponade.

**Results:** A total of 5698 consecutive patients were assigned to 2 groups: 3045 to the SCT and 2653 to the MCT group. Patients in the SCT group were older, more often female and less likely to undergo isolated coronary artery bypass graft than those in the MCT group. Unadjusted outcomes for SCT and MCT, respectively, were return to the operating room for bleeding or tamponade (4.7% v. 5.0%; $p$ = 0.50), intensive care unit stay longer than 48 hours (25.5% v. 27.9%; $p$ = 0.041, postoperative stay > 9 days (31.5% v. 33.1%; $p$ = 0.20) and mortality (3.8% v. 4.6%; $p$ = 0.16). Logistic regression analysis, adjusted for clinical differences between groups, showed that the number of chest tubes was not associated with return to the operating room for bleeding or tamponade.

**Conclusion:** The use of multiple mediastinal chest tubes after cardiac surgery confers no advantage over a single chest tube in preventing return to the operating room for bleeding or tamponade.

**Contexte :** De tout temps, lors de chirurgies cardiaques, on a posé 1 ou plusieurs drains thoraciques médiastinaux pour gérer les saignements. Or, il n'a pas été démontré que la pose de plusieurs drains plutôt que d'un seul confère un avantage.

**Méthodes :** On a posé au moins un drain thoracique à tous les patients consécutifs soumis à une chirurgie cardiaque (2005–2010) au moment de l'intervention, selon la préférence des chirurgiens. Les patients ont été regroupés selon qu'on leur avait posé un seul drain thoracique (SDT) ou plusieurs (PDT). Le paramètre principal était le retour au bloc opératoire pour hémorragie ou tamponnade.

**Résultats :** En tout 5698 patients consécutifs ont été scindés en 2 groupes : 3045 dans le groupe SDT et 2653 dans le groupe PDT. Les patients du groupe SDT étaient plus âgés, plus souvent de sexe féminin et moins susceptibles de subir un pontage aortocoronarien isolé comparativement au groupe PDT. Les paramètres non ajustés pour les groupes SDT et PDT, respectivement, ont été retour au bloc opératoire pour hémorragie ou tamponnade (4,7 % c. 5,0 %; $p$ = 0,50), séjour de plus de 48 heures à l'unité des soins intensifs (25,5 % c. 27,9 %; $p$ = 0,04), durée du séjour postopératoire > 9 jours (31,5 % c. 33,1 %; $p$ = 0,20) et mortalité (3,8 % c. 4,6 %; $p$ = 0,16). L'analyse de régression logistique ajustée pour tenir compte des différences cliniques entre les groupes a révélé l'absence de lien entre le nombre de drains thoraciques et un retour au bloc opératoire pour hémorragie ou tamponnade.

**Conclusion :** La pose de plusieurs drains thoraciques plutôt que d'un seul après la chirurgie cardiaque ne confère aucun avantage en ce qui concerne le retour au bloc opératoire pour hémorragie ou tamponnade.

 

As a part of standard of care in cardiac surgery, mediastinal and pleural chest tubes are placed to provide drainage of serosanguineous fluids from the mediastinum.[1] This practice has become a standard perioperative procedure to monitor bleeding and possibly prevent complications, such as pericardial effusion, hemothorax and tamponade.[2,3]

Despite their necessity, chest tubes are potentially a source of pain and irritation for patients. Some have suggested that the insertion of more than 1 chest tube per patient may exacerbate pain and discomfort, causing a decrease in ambulation that could negatively influence patient outcome.[4–6] Currently, no evidence-based guideline exists that dictates whether a single (SCT) or multiple chest tubes (MCT) should be used. The number of chest tubes inserted is largely left at the discretion of the individual surgeon based on low-level evidence or traditional practice.

Though the literature suggests that SCT may provide adequate drainage, to our knowledge no studies have compared SCT with MCT in terms of patient outcomes. The objective of our study was to evaluate whether the number of chest tubes used could impact return to the operating room for bleeding or tamponade.

## Methods

We retrospectively collected data on all patients who underwent coronary artery bypass grafting (CABG), valve or combined CABG plus valve surgery via a median sternotomy at the Queen Elizabeth II Health Sciences Centre (QEII HSC) in Halifax, NS, between Jan. 1, 2005, and Dec. 31, 2010. Patients were excluded from final analysis if surgery was not performed via median sternotomy or if they also underwent insertion of a ventricular assistance device, extracorporeal membrane oxygenation, pericardectomy, transmyocardial laser revascularization or a complex congenital procedure. Patients were grouped according to whether they received SCT or MCT at the time of their original operation.

### *Operative technique*

During the study period 10 different cardiac surgeons practised in Halifax. The choice of SCT or MCT was entirely left to surgeon preference rather than fixed criteria. All interventions were performed via a midline sternotomy, and cardiopulmonary bypass was performed in a standardized manner. Briefly, body temperature during the procedure was allowed to drift to 32°C. Intermittent cold cardioplegia solution (a blood: crystalloid ratio of 1:4 at a temperature of 8–10°C) was delivered antegrade via the aortic root unless otherwise indicated. Patients in the SCT group had their drainage tube placed on the surface of the diaphragm into the pericardial well. Patients in the MCT had a combination of mediastinal and/or pleural positioning for the drainage tube. In most patients, the chest tube used was a modified 32-FR urethral catheter (Bard) in which additional holes were made to improve drainage from the mediastinum.

In all cases in which an internal mammary artery was used, the pleura was opened unless lung adhesions were present. The pericardium was left open to allow communication with the pleural space when opened to allow for serosanguinous drainage from the mediastinum to pleural space. It was standard practice that all drainage tubes were removed within 24 hours of surgery unless a persistent air leak was present or the patient experienced severe bleeding (> 50 mL/hr).

### *Data sources*

Data were obtained from the Maritime Heart Centre Cardiac Surgery Registry, which is a clinical database that contains pre-, intra- and postoperative information on all patients undergoing cardiac surgery at the QEII HSC. This study was conducted with the full approval of the Capital District Health Authority Research Ethics Board. The requirement to obtain informed consent was waived under Section 2.1c of the Tri-Council Policy Statement. All personal identifiers were stripped before data analysis to ensure patient anonymity and confidentiality.

### *Variable selection*

Preoperative variables of interest included age, sex, left ventricular ejection fraction (EF), diabetes, hypertension, serum creatinine, congestive heart failure (CHF) and chronic obstructive pulmonary disease (COPD). Procedure-related variables were isolated CABG, isolated valve, CABG plus valve, and CABG and/or valve plus other procedure. Urgency of surgery was categorized as emergent (immediate), urgent (within 24 hours), in-hospital (hospitalization required before surgery) or elective (waiting at home).

### *Statistical analysis*

Categorical variables were reported as frequencies and percentages and were analyzed using a $\chi^2$ or Fisher exact test, as appropriate. Design variables were created for reference-level coding of categorical variables with more than 2 levels. A nonparsimonious multivariate logistic regression model was generated to examine the association of SCT and MCT with return to the operating room for bleeding or tamponade, adjusting for clinical differences between groups. Model discrimination was assessed by the area under the receiver operating characteristic (ROC)

curve. We performed a bootstrap procedure to obtain 1000 subsamples with replacement, and the 95% confidence interval (CI) of the ROC was obtained from the 2.5 and 97.5 percentiles of the bootstrap distribution. Model calibration was assessed using the Hosmer–Lemeshow goodness of fit statistic and applying linear regression analysis to the calibration plot of deciles of observed versus predicted mortality. We considered results to be significant at $p < 0.05$. All statistical analyses were performed using the SAS software package version 9.3.

## Results

### *Study population*

A total of 5698 consecutive patients were included in our study. All patients were assigned to 2 groups based on the number of chest tubes placed at completion of the surgery: 3045 patients in the SCT and 2653 patents in the MCT group. Figure 1 illustrates the frequency of the use of MCT among 10 cardiac surgeons within our institution. The figure demonstrates how 5 surgeons predominantly used MCT in every patient, whereas 4 surgeons used MCT in 5% or fewer patients and, as such, used predominantly SCT.

### *Unadjusted univariate comparison between groups*

The characteristics of the study patients are shown in Table 1. Patients in the SCT group were older, more often female, less likely to undergo isolated CABG and more likely to undergo a valve procedure than patients in the MCT group. The unadjusted outcomes between the groups are shown in Table 2. The overall unadjusted in-hospital mortality was 4.2% (3.8% in the SCT group v. 4.6% in the MCT group, $p = 0.16$). Similarly, 26.6% of patients required a stay in the intensive care unit (ICU) longer than 48 hours (25.5% in the SCT group v. 27.9% in the MCT group, $p = 0.041$) and 32.2% had a postoperative stay longer than 9 days (31.5% in the SCT group v. 33.1% in the MCT group, $p = 0.20$). Patients in the SCT group had a lower occurrence of internal mammary artery use than those in the MCT group (49.2% v. 50.7%, $p < 0.001$; Table 2).

A total of 276 (4.8%) patients returned to the operating room for bleeding or tamponade, and there was no significant difference between groups (4.7% in the SCT group v. 5.0% in the MCT group, $p = 0.50$). Blood products were required in 35.6% of patients (33.2% in the SCT group v. 38.3% in the MCT group, $p < 0.001$). Similarly, significantly more red blood cells, fresh frozen plasma, platelets

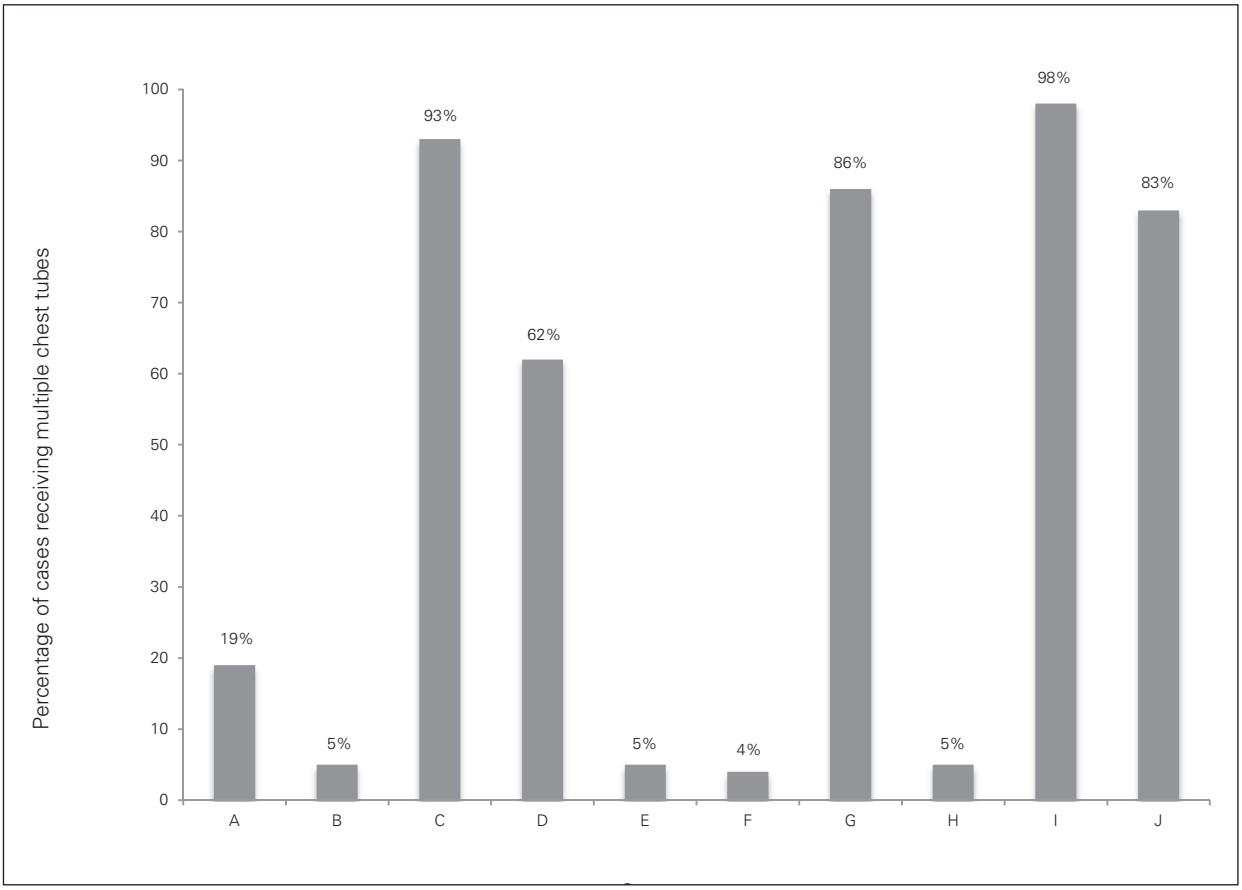


**Fig. 1.** Surgeon use of chest tubes. Each letter represents a single surgeon. The results are expressed as a percentage of the total number of cases performed by each surgeon.

and cryoprecipitate were used in patients in the MCT group than those in the SCT group (Table 3).

### *Nonparsimonious multivariate model to predict return to the operating room for bleeding or tamponade*

We created a nonparsimonious multivariate logistic regression model to adjust for the differences between the SCT and MCT groups. Variables that emerged as independent predictors of return to the operating room for bleeding or tamponade were urgent/emergent surgery (odds ratio [OR] 2.1, 95% confidence interval [CI] 1.4–3.2), in-house surgery (OR 1.5, 95% CI1.1–2.0), renal dysfunction with creatinine greater than 176 µmol/L (OR 1.6, 95% CI 1.0–2.5), age 80 years or older (OR 2.4, 95% CI 1.6–3.6), CABG plus valve surgery (OR 2.2, 95% CI 1.5–3.1) and CABG and/or valve plus other procedure (OR 2.4, 95% CI 1.7–3.6; Fig. 2). What is novel about our predictive model is that we also included individual surgeons as variables. Some surgeons emerged as independent predictors of the primary outcome or return to the OR, whereas others were protective and were less likely to return to the OR. Particularly relevant to the present study is the fact that the number of chest tubes used was not predictive of returning to the OR after adjusting for clinical differences between groups (OR 1.0, 95% CI 0.7–1.4). The ROC of the logistic regression model was 70% with a 95% CI of 68%–74%.

In the present study we did not look systematically at the prevalence of radiographic pleural effusions. We did, however, look at the prevalence of thoracentesis

**Table 1. Demographic and clinical characteristics of patients who received single or multiple chest tubes during the study period**

| | Group, no. (%) | | |
|---|---|---|---|
| Characteristic | SCT, *n* = 3045 | MCT, *n* = 2653 | *p* value |
| Age, yr | | | 0.004 |
| ≥ 80 | 366 (12.0) | 256 (9.6) | |
| 70–79 | 933 (30.6) | 801 (30.2) | |
| 60–69 | 887 (29.1) | 865 (32.6) | |
| < 60 | 859 (28.2) | 731 (27.6) | |
| Female sex | 876 (28.8) | 633 (23.9) | < 0.001 |
| Chronic renal failure | | | 0.57 |
| Creatinine > 176 µol/L | 182 (6.0) | 158 (6.0) | |
| Creatinine 110–176 µol/L | 712 (23.4) | 652 (24.6) | |
| Creatinine < 110 µol/L | 2151 (70.6) | 1843 (69.5) | |
| Diabetes | 1029 (33.8) | 952 (35.9) | 0.10 |
| Ejection fraction ≤ 50% | 872 (28.8) | 746 (28.3) | 0.68 |
| COPD | 478 (15.7) | 431 (16.2) | 0.57 |
| Urgency of the procedure | | | 0.44 |
| Elective | 1420 (46.6) | 1246 (47.0) | |
| In-hospital | 1295 (42.5) | 1095 (41.3) | |
| Urgent/emergent | 330 (10.8) | 312 (11.8) | |
| Type of procedure | | | < 0.001 |
| Isolated CABG | 1669 (54.8) | 1862 (70.2) | |
| Isolated valve | 685 (22.5) | 334 (12.6) | |
| CABG and valve | 344 (11.3) | 252 (9.5) | |
| CABG and/or valve plus other procedure | 347 (11.4) | 205 (7.7) | |

CABG = coronary artery bypass graft; COPD = chronic obstructive pulmonary disease; MCT = multiple chest tubes; SCT = single chest tube.

**Table 2. Unadjusted major morbidity and mortality outcomes between patients who received single or multiple chest tubes during the study period**

| | Group, no. (%) | | |
|---|---|---|---|
| Outcome | SCT, *n* = 3045 | MCT, *n* = 2653 | *p* value |
| Return to OR for bleeding or tamponade | 142 (4.7) | 134 (5.0) | 0.50 |
| In-hospital mortality | 116 (3.8) | 121 (4.6) | 0.16 |
| ICU stay > 48 hours | 775 (25.5) | 739 (27.9) | 0.041 |
| Postoperative stay > 9 d | 959 (31.5) | 878 (33.1) | 0.20 |
| IMA use | 1788 (49.2) | 1844 (50.7) | < 0.001 |

ICU = intensive care unit; IMA = internal mammary artery; MCT = multiple chest tubes; OR = operating room; SCT = single chest tube.

while in hospital. The unadjusted rates of thoracentesis suggest that the overall prevalence was low and did not differ between the SCT and MCT groups (1.4% v. 1.3%, $p = 0.67$).

## Discussion

There is a paucity of literature to support the use of either SCT or MCT in cardiac surgery. Most of the recent

**Table 3. Blood products used in patients who received single or multiple chest tubes during the study period**

| | Group, no. (%) | | |
|---|---|---|---|
| Variable | SCT, $n = 3045$ | MCT, $n = 2653$ | $p$ value |
| RBC | 947 (31.1) | 937 (35.4) | < 0.001 |
| FFP | 294 (9.7) | 434 (16.4) | < 0.001 |
| Platelets | 228 (7.5) | 409 (15.4) | < 0.001 |
| Cryoprecipitate | 71 (2.3) | 223 (8.4) | < 0.001 |

FFP = fresh frozen plasma; MCT = multiple chest tubes; RBC = red blood cells; SCT = single chest tube.

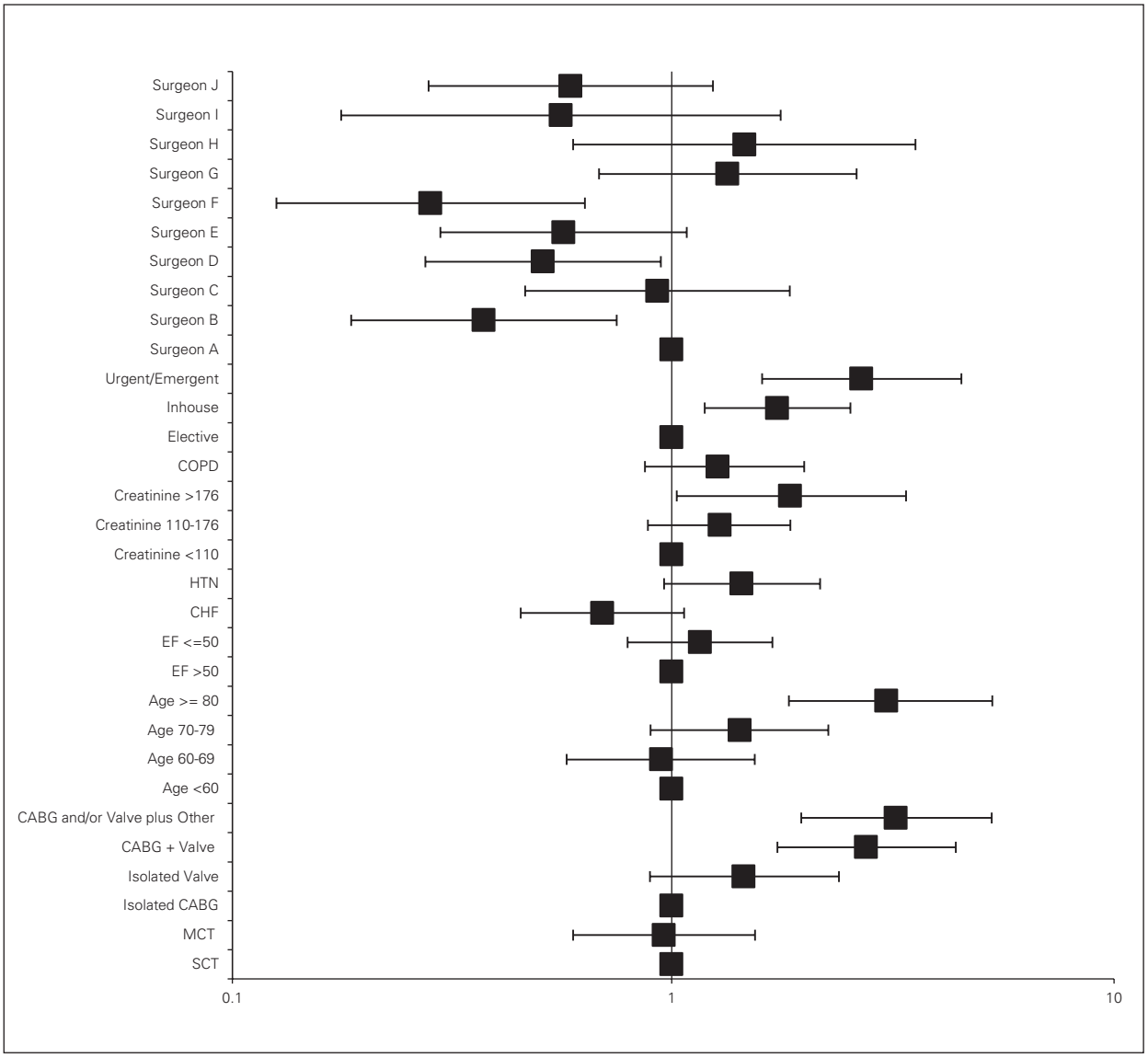


**Fig. 2.** Adjusted odds ratios on a logarithmic scale showing our findings from the multivariate analysis designed to evaluate predictors of return to the operating room for bleeding or tamponade. CABG = coronary artery bypass graft; CHF = congestive heart failure; COPD = chronic obstructive pulmonary disease; EF = ejection fraction; HTN = hypertension; MCT = multiple chest tubes; SCT = single chest tube.

literature has focused on the type of drainage tubes used.[1,7] The choice of the number of chest tubes used has traditionally been based on surgeon preference, which in turn has largely been derived from their experience, training or institutional policies. This was clearly illustrated in our data: some surgeons used predominantly SCT, whereas others used MCT regardless of the surgical procedure performed. One needs to acknowledge that the choice to use 32-FR urethral catheters as chest tubes is unusual and was based on a long-established history of their use in our institution. We claim without clear proof that these tubes are soft and malleable, allowing for additional drainage holes to be added easily (by simply cutting extra holes) and are convenient for stripping when the patient is in the ICU to ensure that patency is maintained. Our findings and practice have not been compared with newer chest tube technologies, such as Blake drains, or tubes with differing methods of mechanical active tube clearance technologies that are currently available as alternative means of drainage. The literature is inconclusive with respect to the superiority of these new technologies. To date, a limited number of publications are available, suggesting that it has been traditionally difficult to prove 1 method of drainage is superior to another.[11,12]

The primary outcome of our study was to determine if the number of chest tubes used could impact return to the operating room for bleeding or tamponade. Using a logistic regression analysis to adjust for the clinical differences between patients in the SCT and MCT groups, we were unable to demonstrate whether the number of chest tubes used predicted return to the operating room or was protective.

We did, however, identify several important predictors of return to the operating room for bleeding or tamponade. These independent predictors, such as urgent procedures, complex procedures and renal dysfunction,[8] are not surprising given their association with bleeding risk. For reasons that are unclear, age 80 years or older was shown to be an independent predictor of return to the operating room. The implications for this observation are important as an increasing number of octogenarians undergo cardiac surgery, suggesting that special considerations, such as the use of antiplatelet agents and perioperative anticoagulants, should be considered to reduce this risk in these patients.[9]

We were able to demonstrate how the operating surgeon was predictive of return to the operating room, either by increasing or decreasing the likelihood independent of patient or procedure variables. This observation likely illustrates variations in clinical practices in which a variable threshold exists for returning to the operating room.

### *Limitations*

We acknowledge this study was not designed to capture all the benefits or harms of using SCT or MCT. We chose our primary outcome based on the primary function of chest tubes being drainage of serosanguinous fluids from the mediastinum, which as such is a surrogate predictor of fluid accumulation (return to the operating room for bleeding or tamponade). The present study was retrospective and therefore not designed to capture detailed information on total chest tube drainage or radiographic evidence of pleural effusion, which is not available in our registry. Furthermore, our study cannot fully address differences among surgeons, including the possibility that some surgeons using more than 1 chest tube (MCT group) may have limited their incidence of return to the operating room if they had only used 1 chest tube.

Despite these limitations, and in support of our findings, we report an unadjusted prevalence of thoracentesis that was low and that did not differ between groups, suggesting that the use of chest tubes may have minimal clinical impact on the prevalence of pleural effusion. We can also say that the unadjusted prevalence of blood product use as a surrogate for bleeding was not higher in the SCT than the MCT group, which could have masked inappropriate drainage. However, one should note that detailed information on the exact time all antiplatelet agents or anticoagulants were stopped before surgery was not available for analysis, but could explain why urgency independently increased the likelihood of return to the operating room for bleeding. The standard practice in our institution is to maintain the use of acetylsalicylic acid but to hold clopidogrel for a minimum of 48 hours unless patients require urgent surgery.

## Conclusion

Our study indicates that within our institution the use of MCT offered no overall benefit compared with SCT after cardiac surgery in terms of limiting the risk of returning to the operating room for bleeding or tamponade. Furthermore, others have shown that MCT can result in severe postoperative pain and discomfort.[4–10] Thus, we advocate the use of SCT in patients undergoing open heart surgery. However, these results should be interpreted with caution given the limitations outlined in our discussion.

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**Competing interests:** None declared.

**Contributors:** J. Le and J.-F. Légaré designed the study. K. Buth acquired the data, which all authors analyzed. J. Le wrote the article, which all authors reviewed and approved for publication.

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