REVIEW ARTICLE

THE IMPACT OF ACTIVE CHEST TUBE CLEARANCE TECHNOLOGY ON SURGICAL OUTCOMES AFTER CARDIAC SURGERY: AN UPDATED SYSTEMATIC REVIEW AND META-ANALYSIS

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Abstract

Objective: *Active chest tube clearance technology (ACT) systems were introduced to improve the patency of chest tubes and to reduce the potential complications associated with inadequate mediastinal blood drainage after cardiac surgical procedures. The purpose of this study is to assess the impact of ACT on the incidence of chest tube clogging, retained blood syndromes (RBS), re-exploration for bleeding, and the incidence of postoperative atrial fibrillation (POAF) after cardiac surgical procedures.*

Methods: *A database search was conducted using Medline, Embase, Cochrane Library, and Web of Science. Only articles comparing the use of ACT to conventional chest tube drainage after cardiac surgery were screened. Included articles were restricted to adult patients and English language only.*

Results: *Nine of the 841 articles screened were included in this review. Two studies were randomized controlled trials (RCT) and seven were observational studies. Pooled estimates showed RBS, surgical re-exploration rates, and POAF were significantly less common in the ACT group.*

Conclusion: *Our meta-analysis suggests that the use of ACT may be beneficial in reducing the incidence of postoperative complications associated with inadequate drainage of mediastinal blood after cardiac surgery. However, more robust evidence is required to endorse these findings and support the routing use of ACT in clinical practice.*

Keywords: *Cardiac Surgery, Active Clearance Technology, Mediastinal drains, Chest drains, Re-exploration, Postoperative bleeding*

INTRODUCTION

Post-operative bleeding is commonly associated with increased morbidity, mortality, surgical re-exploration, hospital costs, and length of stay[1]. The use of chest tube draining systems following cardiac surgical procedures is an established gold standard practice. Complications arising from inadequate mediastinal blood drainage can include cardiac tamponade[2], retained haemothorax[3], and postoperative atrial fibrillation[4]. The primary goal of a chest drainage system is to facilitate the adequate drainage of the accumulated post-surgical blood[5]. To accomplish this, conventional chest tubes are connected to an under-water seal system with low-pressure negative suction[6]. Manipulation methods such as milking, stripping, and fan folding have been utilized to enhance the drainage but with minimal efficacy and with reported risks of potential adverse effects[2].

Chest tube clogging can interfere with the free flow of mediastinal blood resulting in inadequate drainage.

The incidence of chest tube clogging is variable, with one prospective observational study reporting an incidence of 36% in their patients[7]. Unfortunately, poor drainage is commonly underestimated as tube clogging in its in-body portion often goes unnoticed during bedside inspection[7]. Incomplete evacuation of blood due to chest tube clogging can also cause RBS, defined as the acute, subacute, or chronic collection of blood requiring removal from the pericardial or pleural spaces. RBS is commonly associated with complications such as cardiac tamponade, pericardial effusion, constrictive pericarditis, retained haemothorax, and POAF[8,9].

The association between inadequate mediastinal blood drainage and the increased incidence of POAF has been described by multiple authors making it important to analyse if a more efficient chest drainage system would result in reducing its incidence [4,8,9,10]. The underlying mechanism of POAF is multifactorial but it has been suggested that it may be triggered by oxidative stress and atrial inflammation from retained blood[4].

These cited reasons have led to the development of the commercially available Pleuraflow® Active Clearance Technology (ACT, ClearFlow, Inc, Anaheim, CA) system. This system consists of an external silicon chest tube, an internal guidewire and a loop that can be moved within the tube to mechanically disrupt blood clots[11]. The forward and backward movement of the guidewire and loop is driven by two sets of magnets on the outside of the tube[11]. Frequent manual dislodgement of blood clots is then applied as per an established protocol until chest tubes are eventually removed. This protocol consists of using the device every 15 minutes during the first 8 hours after placement, every 30 minutes for the next 16 hours, then every hour thereafter. It is advised to use at least one PleuraFlow® system in the anterior mediastinum where bleeding is most common[11]. This system is available in 4 different chest tube sizes (20,24,28, and 32 French) and can be used for both pleural and pericardial spaces[11].

Of note, the Enhanced Recovery after Cardiac Surgery (ERAS Cardiac) society has acknowledged the benefits of using ACT technology in adult cardiac surgical patients. The 2019 ERAS Guidelines for Perioperative Care in Cardiac Surgery have mentioned chest tubes manipulation techniques (such as milking and stripping) and recommended against their routine use in the early postoperative period[12].

In this review, we investigate the impact of the use of ACT systems, as compared to the use of conventional chest tube drainage systems, after cardiac surgery in terms of reducing the incidence of chest tube clogging, retained blood syndrome, surgical re-exploration for evacuation of accumulated blood, and the incidence of postoperative atrial fibrillation.

MATERIALS AND METHODS

Study design and search strategy

The design and protocol of this study was formulated and submitted for registration with Prospero (CRD42022307229). In June 2022, a database search was conducted using Medline, Embase, Cochrane Library, and Web of Science to identify relevant studies. The following keywords and subject headings were used: "Chest Drainage" AND "Chest Tube" AND "Cardiac Surgery". Results were restricted to adult populations and papers published in English. There were no date restrictions.

Study Selection and Outcomes

Following the database search as described, the identified research papers were evaluated using Covidence software (Veritas Health Innovation, Melbourne, Australia. Available at www.covidence.org) by two independent reviewers (BA & VY), with divergences resolved by consensus. Reviewers were not blinded to the authors' names or institution of the studies. Duplicates were first removed, then titles and abstracts were screened. The remaining studies underwent a full-text evaluation to identify only those studies that fulfilled the inclusion criteria. The study selection process is shown in a Preferred Reporting Items for Systematic Reviews and Meta- Analyses (PRISMA) flowchart (Supplementary Figure 1)[13].

We included comparative studies (RCTs and cohort studies) that compared the use of active tube clearance protocols versus conventional chest tubes in adult patients undergoing cardiac surgical procedures. Case reports, editorials, and other reviews were excluded. The outcomes of interest were rates of chest tube clogging, retained blood syndrome, surgical re-exploration for blood evacuation, and postoperative atrial fibrillation.

Data Extraction, and Quality Assessment

A study characteristics table was created to summarize the selected sources. Study design, sample size, inclusion and exclusion criteria, baseline patient demographics, and outcomes were all studied. Due to significant variability between the format of reported results, a standardised data summary table was not created. Instead, the relevant reported results are discussed in their respective sections.

Two independent reviewers (BA & VY) appraised study quality with divergences resolved by consensus. Quality assessment for observational studies was performed using the Newcastle-Ottawa scoring scale for assessing the quality of nonrandomised studies in meta-analyses. Each trial was assigned an overall quality score according to the above criteria (Supplementary Table 1).

Quality assessment for randomized studies was conducted using the Cochrane Collaboration Methods (ie. judging the risk for selection, performance, attrition, and adjudication biases) and expressed as a low risk of bias (green), high risk of bias (red), or incomplete reporting leading to inability to ascertain the underlying risk of bias (yellow) (Supplementary Table 2).

Statistical Analysis

Random effects meta-analysis was performed using the restricted maximum-likelihood estimator with Hartung-

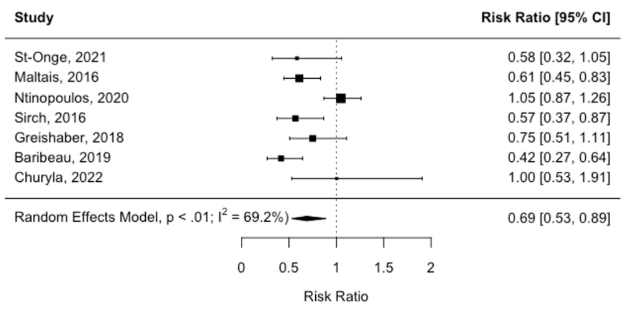


Figure 1 A *Pooled analysis of rates of retained blood syndromes in active chest tube clearance vs. conventional management.*

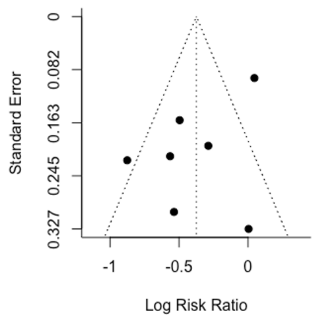


Figure 1 B *Results of Egger's Regression Test testing publication bias in studies examining retained blood syndromes.*

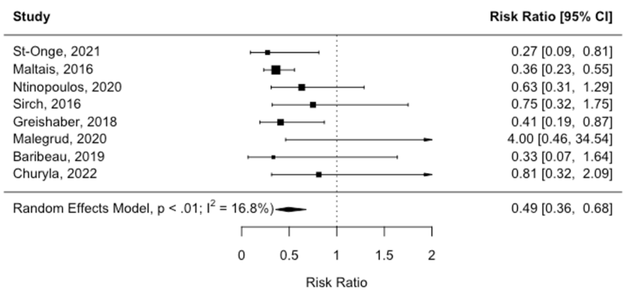


Figure 1 C *Pooled analysis of surgical re-exploration rates in active chest tube clearance vs. conventional management.*

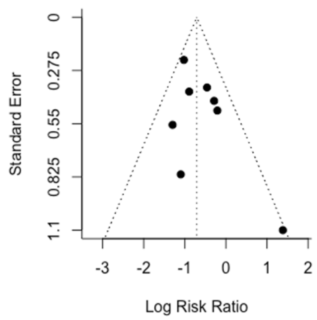


Figure 1 D *Results of Egger's Regression Test testing publication bias in studies examining surgical re-exploration.*

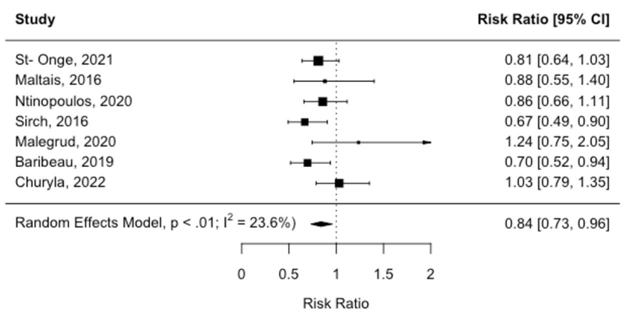


Figure 1 E *Pooled analysis of rates of POAF in active chest tube clearance vs. conventional management.*

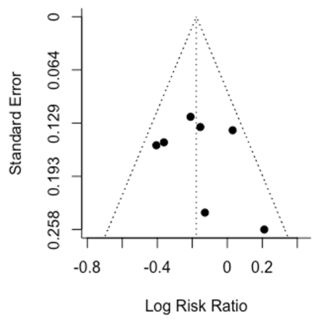


Figure 1 F *Results of Egger's Regression Test testing publication bias in studies examining POAF.*

Knapp adjustment. For dichotomous variables, the Mantel-Haenszel method was used to calculate the risk ratio (RR) and it is reported with 95% confidence interval (95% CI). Publication bias was assessed subjectively using a funnel plot and quantitatively using Egger's regression test. The analyses were performed using the metafor package for R version 3.01 (R Core Team 2022). Statistical heterogeneity was evaluated using I2, with 25%, 50%, and 75% deemed as low, moderate, and high heterogeneity, respectively. P-values <0.05 were considered significant.

RESULTS

Study population

There were nine studies (4980 patients) included in this review as shown in Table 1. Of these, two were randomised studies and seven were observational studies. From an original 1167 articles, 326 duplicates were excluded. Title and abstract screening were conducted on the remaining 841 articles, rendering 15 articles for full text review. Reasons for excluding articles in this final stage are shown in Supplementary Figure 1.

Quality Assessment

The seven observational studies were assessed in Quality by using the Newcastle-Ottawa scale. The Newcastle-Ottawa scale scores were converted to Agency of Healthcare Research and Quality (AHRQ) standards, all seven studies were found to be of Good Quality by both independent reviewers (Supplementary Table 1).

The two randomized studies included in this paper were assessed using the Cochrane collaboration tool, and both demonstrated low or unclear risk of bias within the domains of selection bias, allocation bias, performance bias, detection bias, attrition bias, and reporting bias (Supplementary Table 2).

Study outcomes

Chest tube clogging

Clogging was determined by visual inspection, and classified as either patent, partially or completely obstructed. Only one study included in this review examined complete chest tube clogging as an outcome. This is shown in Supplementary Table 3.

Retained blood syndrome and surgical re-exploration for bleeding

There were nine studies included in this review that examined RBS or surgical re-exploration for bleeding as an outcome. Of these, two were RCTs while seven were observational studies. These studies are summarised in Table 1a and Table 1b. RBS occurs when complications arise from retained intrathoracic blood requiring intervention. It was therefore defined and measured by all seven studies as a composite of re-exploration for bleeding, percutaneous and surgical pleural interventions (i.e. thoracentesis, thoracotomy or thoracoscopy for hemothorax after surgery), and pericardial interventions (i.e. pericardial window or pericardiocentesis). Pooled analysis showed a significant reduction in rates of RBS (RR = 0.69; 95%CI = 0.53-0.89; I2 = 69.2%; p = <0.01; Figure 1A) with active chest tube clearance, with a high level of heterogeneity between studies. There was no evidence of publication bias for all pooled outcomes, and this was confirmed by the Egger's regression Test (Figure 1B). Similarly, rates of surgical re-exploration were found to be significantly lower (RR = 0.49; 95%CI = 0.36-0.68; I2 = 16.8%; p = <0.01; Figure 1C) with active chest tube clearance compared to conventional method. There was no evidence of publication bias for all pooled outcomes, and this was confirmed by the Egger's regression Test (Figure 1D).

Postoperative atrial fibrillation

There was a total of seven studies in this review that examined POAF as an outcome. These studies are shown in Table 1E and included two randomized studies and five observational studies. Most of the studies defined POAF as the incidence of an episode of POAF lasting at least 60 minutes at any point from the conclusion of surgery to hospital discharge. Pooled analysis showed a significant reduction in rates of post-operative atrial fibrillation (RR = 0.84; 95%CI = 0.73-0.96; I2 = 23.6%; p = <0.01; Figure 1E) with active chest tube clearance. There was no evidence of publication bias for all pooled outcomes, and this was confirmed by the Egger's regression Test (Figure 1F).

DISCUSSION

Conventional chest tube clogging can result in retained mediastinal blood after cardiac surgery. Despite several techniques, such as tube milking and stripping having been described to improve chest tube patency, these have not proven to be effective in preventing tube occlusion. Additionally, these techniques can potentially be associated with worsening bleeding due to the generation of extreme negative suction pressure, as low as - 400 mmHg, which may further enhance bleeding from raw and oozing surfaces[15,16,17]. Another proposed technique is chest tube suctioning; however, this involves the mechanical disruption of the sterile closed suctioning system[16]. It is important to highlight that seven of the nine studies included in our review employed these techniques in their conventional chest tubes treatment arm. Also, it is a common practice by many surgeons to use bigger diameter chest drains to reduce the likelihood of drain clogging, however, this can be associated with more pain and less comfort to the patients[15]. With the introduction of less invasive surgical techniques and the tendency to use fewer and smaller calibre chest tubes to limit the incision size, the development of efficient chest drainage systems has become more in demand[15].

In their randomized clinical trial, St-Onge et al.[4] showed that ACT chest tubes are significantly less likely to completely clog than their conventional counterparts. However, the rate of partial obstruction was similar between the 2 groups. As

Table 1 **Pivotal Trials in NSCLC unselected by PD-L1 expression**

First Author, Year of Publication	Design	Population	n	Comparators	Tube Removal	Unclogging technique used with conventional tubes	Outcomes of Interest
St-Onge, 2021	Randomized	Adult non-emergent CABG and/or valvular heart surgery through median sternotomy patients	e520	2 arms, ACT(n=257) or standard drainage with conventional chest tubes(n=263)	Mediastinal chest tubes were removed 24h after the index surgery or when drainage volume was less than 50mL during the previous 8h. Pleural and silastic drains were removed 48 h after the index surgery or when drainage volume was less than 150mL during the past 24 h.	Milking and stripping used. Direct aspiration when necessary	Re-exploration RBS Chest tube clogging POAF
Maltais, 2016	Observa-tional	Adult patients undergoing LVAD implantation	252	175 with ACT, 77 with conventional chest tubes	Not described	Stripping, milking, fan folded	Re-exploration RBS POAF
Ntinopoulos, 2020	Observational	Adult patients undergoing major cardiac surgery (coronary artery bypass surgery, valve surgery, thoracic aortic surgery and their combinations)	2461 total, 942 included in propensity matched analysis	2 arms, ACT (n=471 after matching) or standard drainage with conventional chest tubes (n=471 after matching)	Chest tubes were removed when draining less than 100 ml over 8 hours postoperatively or when the drainage volume was less than 200 ml during the previous 24 hours.	Milking and Stripping	RBS Re-exploration POAF
St-Onge, 2017	Observational	Patients undergoing cardiac surgery	300 total, 214 included in propensity matched analysis	2 arms, ACT (n=107 after matching) or standard drainage with conventional chest tubes (n=107 after matching)	Not described	Direct aspiration when necessary	Re-exploration POAF
Sirch, 2016	Observational	Adult patients undergoing cardiac surgery (coronary artery bypass grafting [CABG], valve, CABG + valve, and other)	2327 total, 444 included in matched analysis	ACT (n=222 after matching) or standard drainage with conventional chest tubes (n =222 after matching)	After 24 hours, the chest tube with ATC was removed, or the chest tube was left in place and the ATC pulled back and its use was discontinued. Most were removed by the second postoperative day.	Milking and stripping	RBS Re-exploration POAF
Greishaber, 2018	Observational	Patients scheduled (elective or urgent) for cardiac surgical procedures with median full sternotomy or partial sternotomy	581 total, 444 included in propensity matched analysis	ACT (n=222 after matching) or standard drainage with conventional chest tubes (n =222 after matching)	chest tubes were removed if drainage volume was less than 300 mL during the past 12 hours or when only serous drainage loss was observed	Milking at least once an hour	RBS Re-exploration

First Author, Year of Publication	Design	Population	n	Comparators	Tube Removal	Unclogging technique used with conventional tubes	Outcomes of Interest
Malegrud, 2020	Randomized	Primary elective aortic valve surgery	100 patients	2 arms, ACT(n=50), conventional Argyle chest tubes(n=50)	The chest tubes were removed when there was less than 10 mL/h serosanguinous drainage output.	None	POAF Re-exploration
Baribeau, 2019	Observational	Adult cardiac surgery patients	697 total	ACT (n=260 after matching), conventional chest tubes (n=260 after matching)	Mediastinal chest tubes were removed 24 h postoperatively or when drainage volume was less than 50 mL during the previous 8 h. Pleural chest tubes were removed 48 h post-operatively or when drainage volume was less than 200 mL during the past 24 h.	Milking	RBS Re-exploration POAF
Churyla, 2022	Observational	Cardiac Surgery Patients	1367 total	254 with ACT tubes, 1113 with conventional chest tubes	Not described	None	RBS POAF Re-exploration

CABG = Coronary artery bypass graft, LVAD = Left ventricular assist device, ACT = Active chest tube clearance technology, RBS = Retained blood syndrome, POAF = Postoperative atrial fibrillation

per the author's acknowledgement, this is the sole study to date showing evidence of reduced chest clogging with ACT protocols[14]. It was suggested that ACT might reduce bleeding, as among patients who underwent surgical re-exploration, active bleeding was less observed in the ACT group when compared to the conventional chest tubes group[17]. The exact mechanism by which ACT results in less bleeding is unclear, however, a few theories have been postulated. First, the ACT does not result in changes in negative intra-thoracic pressure, this may result in less disruption of freshly formed blood clots around small vessels in the chest wall or small side branches of coronary bypass grafts[17]. Second, the continuous evacuation of retained mediastinal blood may result in the elimination of tissue Plasminogen Activator (t-PA) and other thrombolytic enzymes which may play an important role in coagulopathic bleeding[17,20]. Third, it is generally accepted that retained blood in the pericardium and pleural spaces undergoes inflammatory changes that involve the release of vascular endothelial growth factor (VEGF) and other inflammatory markers. Over days, this may result in fluid formation that may require intervention or re-exploration[14,17,19,20]. Therefore, limiting retained blood by using ACT may result in the interruption of this inflammatory process and the reduction of pericardial and or pleural effusions.

The reported effectiveness of ACT on the incidence of re-interventions for RBS or surgical re-exploration for acute bleeding has been inconsistent but the overall trend suggests that the use of ACT may be beneficial in reducing these complications[14,17,18,19,20,21]. Reported RBS complications included wash out for mediastinal clots or hemothorax, the insertion of an additional chest tube, and thoracentesis or pericardial drainage for effusions[20]. These discrepancies may be explained by the multifactorial nature of postoperative pleural or pericardial effusions and that perioperatively retained fluid might not be the most significant factor in their formation[17]. Also, there were significant differences in terms of ACT management protocols with varying suctioning intervals applied by different teams (15-30 minutes in the immediate postoperative period). Additionally, the number of ACT drains per patient and the locations of these drains varied significantly between these studies, however, it was suggested that using one ACT device might be sufficient as the addition of a second ACT device did not increase the effect on relevant outcome parameters[17]. It is also very important to highlight that the decision to re-explore a patient for bleeding is complex and involves an assessment of multiple

Table 1a Results of Studies examining Retained blood syndromes

Author, Year of Publication	Number of Arms	Number of Patients in Conventional Chest Tube Protocol Arm (control)	Number of Patients in Active Chest Tube protocol (intervention)	Number of patients with RBS in Conventional Chest Tube Protocol	Number of Patients with RBS in Active Chest Tube Protocol	Conventional RBS Percentage	Active RBS Percentage	P Value	Notes
St- Onge, 2021	2	263	257	28	16	10.60%	6.20%	p=0.07	
Maltais, 2016	2	77	175	NR	NR	51%	31%	p=0.0044	
Ntinopoulos, 2020	2	471	471	148	155	31%	33%	p=0.68	
Sirch, 2016	2	256	256	51	29	19.90%	11.30%	p=0.0087	
Greishaber, 2018	2	222	222	48	36	22%	16%	p=0.015	
Baribeau, 2019	2	260	260	60	25	23%	9.60%	p<0.001	The number needed to treat for this RBS reduction was 7.4 [95% CI 5–14.6, p = 0.001}
Churyla, 2022	2	1113	254	NR	NR	4.30%	5.30%	p=0.527	

RBS = Retained blood syndrome

Table 1b Results of studies examining re-exploration for bleeding

Author, Year of Publication	Number of Arms	Number of Patients in Conventional Chest Tube Protocol Arm (control)	Number of Patients in Active Chest Tube Protocol (intervention)	Number of patients needing Re-exploration for Bleeding in Conventional Arm	Number of patients needing Re-exploration for bleeding in Active arm	Conventional Re-exploration percentage	Active Re-exploration Percentage	P Value
St- Onge, 2021	2	263	257	15	4	5.70%	1.60%	p=0.01
Maltais, 2016	2	77	175	33	27	43%	15%	p<0.001
Ntinopoulos, 2020	2	471	471	19	12	4.00%	3%	p=0.25
St-Onge, 2017	2	107	107	1	3	1%	3%	p=0.62
Sirch, 2016	2	256	256	12	9	4.70%	3.50%	p=0.65
Greishaber, 2018	2	222	222	22	9	9.10%	4.10%	p=0.015
Malegrud, 2020	2	50	50	1	4	2%	8%	p=0.36
Baribeau, 2019	2	260	260	6	2	2.30%	0.70%	p=0.28
Churyla, 2022	2	1113	254	27	5	2.40%	2.00%	p=0.664

Table 1c **Results of studies examining POAF**

Author, Year of Publication	Number of Arms	Number of Patients in Conventional Chest Tube Protocol Arm (control)	Number of Patients in Active Chest Tube Protocol (intervention)	Number of Patients with POAF in Conventional Arm	Number of patients with POAF in Active Arm	Conventional POAF Percentage	Active POAF Percentage	P value	Notes
St- Onge, 2021	2	263	257	101	80	38%	31%	p=0.08	
Maltais, 2016	2	77	175	20	40	26%	23%	p=0.63	
Ntinopoulos, 2020	2	471	471	98	84	22%	19%	p=0.33	
St-Onge, 2017	2	107	107	37	26	35%	24%	p=0.09	ACT drainage protocol was found to be an independent protective factor for POAF with an odds ratio (OR) of 0.5 (95% confidence interval [CI], 0.1-0.9: P = .02)
Sirch, 2016	2	256	256	78	52	30.00%	20.00%	p=0.13	
Malegrud, 2020	2	50	50	17	21	34%	42%	p=0.54	
Baribeau, 2019	2	260	260	79 (n= 214)	55 (n=216)	37%	25.00%	p=0.011	
Churyla, 2022	2	1113	254	221	52	20.20%	20.80%	p=0.837	

POAF = Postoperative atrial fibrillation

hemodynamic, clinical, and biochemical variables. Different teams have different thresholds for take-backs and different management strategies[19]. However, adequate drainage of mediastinal blood and reversal of cardiac tamponade may allow patients with coagulopathic bleeding to remain hemodynamically stable while the coagulation disorder is medically corrected[18].

Similarly, the reported effect of using ACT protocols on the incidence of POAF has been inconsistent[14,18,16,21]. In their randomised control trial, St-Onge et al reported an 18% relative reduction in POAF in the ACT group as compared to the control group. However, this difference did not reach statistical significance (31% vs 38%, p=.08)[12]. It was argued that the study was underpowered to detect the true effect of ACT on difference in POAF. However, this 18% relative reduction in POAF still remains clinically relevant[14]. The study conducted by Malegrud et al.[22], was the lone study that did not show a reduction in POAF with ACT protocols. However, it was a relatively small study that included only 50 patients and was not designed to examine the POAF outcome. The mechanism by which ACT might contribute to the reduction in POAF is not entirely clear. However, it was suggested that retained mediastinal blood could promote local inflammatory and oxidative responses on the surface of the heart during early recovery which may result in triggering POAF[14].

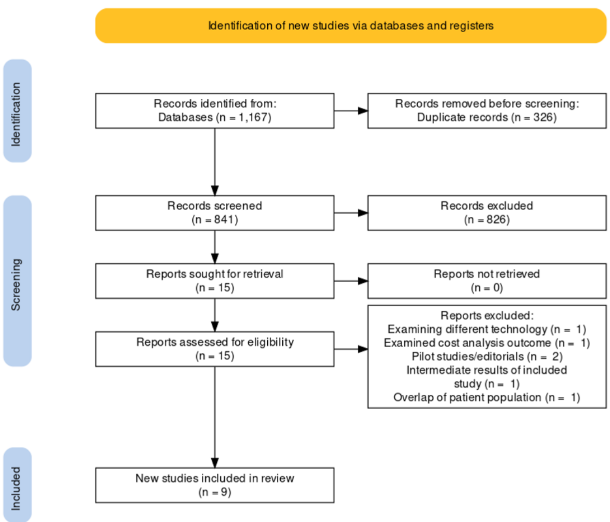
ICU length-of-stay, and total hospital length-of-stay are two other important markers of patient outcomes after cardiac surgery. In this review, six studies examined ICU length-of-stay, of which, one showed a significant reduction in ICU stay in the ACT cohort[20]. Similarly, six studies investigated the

Supplementary Table 1 **Newcastle-Ottawa scoring of observational studies included in study**

Study	AHRQ Standard	Selection	Comparability	Outcome
Maltais, 2016	Good Quality	3	2	3
Ntinopoulos, 2020	Good Quality	4	2	3
St-Onge, 2017	Good Quality	4	2	3
Sirch, 2016	Good Quality	3	2	3
Baribeau, 2019	Good Quality	4	2	3
Churyla, 2022	Good Quality	3	2	3
Greishaber, 2018	Good Quality	3	2	3

Supplementary Table 2 **Cochrane collaboration tool scoring of randomized trials included in review**

Study	Random sequence generation (selection bias)	Allocation Bias	Performance Bias	Detection Bias	Attrition Bias	Reporting Bias
St-Onge, 2021	+	+	?	?	+	+
Malegrud, 2020	+	?	?	?	+	+



Supplementary Figure 1 *PRISMA diagram for inclusion*

hospital length-of-stay, of which, three found a significant reduction in hospital length-of-stay in favour of the ACT group. However, the data reported on these outcomes is thus far equivocal and cannot be generalized.

An initial attempt at establishing the cost-effectiveness was made by St. Onge et al.[4], who conducted a cost-benefit analysis comparing 18 patients who required re-exploration for bleeding or tamponade with patients who did not experience these complications through univariate analysis[23]. The cost benefit analysis was based on average costs of treating various hospital complications incurred by the two groups, and it found an approximate savings of 240 Canadian Dollars when using ACT compared to conventional chest tubes. In their study, Baribeau et al. used a different method, where 337 patients who were treated using ACT technology were compared to 302 patients who were treated with conventional tubes to create 260 propensity matched pairs. Total cost data for patients in the two groups from time of admission to time of discharge were provided by the hospital's finance department. When treating patients with ACT technology, there was a median cost savings of $1831.45 USD (p=0.04), and a mean cost savings of $2696 USD (p=0.116). In their recent study, Salna et al further emphasised on the importance of the cost effectiveness issue, taking into consideration the fact that the Pleuraflow® ACT system costs $495 USD, whereas traditional chest tubes may cost less than $15 USD. Furthermore, they highlight the issue of staffing costs associated with the use of the Pleuraflow® ACT system which requires staff to use the device on a regular schedule. The authors conclude that if the ACT system indeed is effective at reducing complications arising from retained blood, then this device would probably be worth adopting from the financial perspective[24].

LIMITATIONS

This review has some limitations. First, most of the included studies were non-randomized. Second, some studies were not powered enough to detect the true effect of ACT on the outcomes of interest. Third, there were significant differences in terms of study protocols, chest tube management policies, and the number of chest tubes used. Additionally, the inclusion of retrospective studies that relied on databases for data collection may have resulted in missing or incomplete data, and publication bias (in which positive results are more likely to be published) may have influenced the overall effect size. Finally, the lack of patient-level data in this meta-analysis resulted in inability to standardize the analytical techniques used in each study and the direct comparison of the outcomes of interest.

CONCLUSIONS

The use of Active Clearance Technology devices is an emerging tool that shows promising outcomes after cardiac surgery. These devices may help reduce the incidence of postoperative chest tube clogging, retained blood syndrome, surgical re-exploration, and postoperative atrial fibrillation. More robust evidence is required to endorse these findings and to justify their routine use in this group of patients.

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