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## The duration of mediastinal chest tube drainage is not associated with postoperative pain or opioid consumption after cardiac surgery

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### ABSTRACT

**Objectives.** Mediastinal chest tubes are considered to be a significant factor causing postoperative pain after cardiac surgery. The aim of the study was to ascertain whether the duration of mediastinal drainage is associated with postoperative pain and opioid consumption. **Design.** A total of 468 consecutive patients undergoing cardiac surgery at the Tampere University Hospital between December 2015 and August 2016 were retrospectively analyzed. The first 252 patients were treated according to short and the following 216 patients according to extended drainage protocol, in which the mediastinal chest tubes were habitually removed on the first and second postoperative day, respectively. The oxycodone hydrochloride consumption, as well as daily mean pain scores assessed by numeric/visual rating scales, were compared between the groups. **Results.** The mean daily pain scores and cumulative opioid consumption were similar in both groups. Patients with reduced ejection fraction, diabetes, and peripheral vascular disease reported lower initial pain scores. The median cumulative oxycodone hydrochloride consumption did not differ according to the drainage protocol but was higher in males, smokers, and after aortic surgery. In contrast, patients with advanced age, hypertension, and peripheral vascular disease had lower consumption. In multivariable analysis, male sex and aortic surgery were associated with higher and advanced age with lower opioid use. **Conclusions.** The length of mediastinal chest tube drainage is not associated with the amount of postoperative pain or need for opioids after cardiac surgery. Male sex and aortic surgery were associated with higher and advanced age with lower overall opioid consumption.

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### Introduction

The standard median sternotomy commonly used in open cardiac procedures is a complicated surgical access when aiming at modern multimodal pain management. Thoracic epidural analgesia is considered to be the gold standard but there are restrictions limiting its wide-spread use, mostly related to anti-coagulation [1,2]. Opioids are fundamental in treating early postoperative pain but also frequently incur significant adverse effects, such as nausea, malaise, and confusion, and the means for decreasing postoperative pain and consequently opioid consumption are therefore important to determine. The underlying mechanisms behind as well as the optimal management of postoperative pain in cardiac surgery patients are still incompletely defined. Postoperative mediastinal drainage is necessary to prevent excessive accumulation of pericardial effusions. Mediastinal chest tubes are often regarded as a significant factor causing postoperative pain although this has not been verified or extensively discussed in previous literature. Early chest tube removal has been advocated by some [3,4], but both the reduction of patient discomfort and the potential benefits obtained by this approach, are questionable. The hypothesis for this

study was that longer duration of chest tube drainage does not affect postoperative pain and the aim of the present study was to investigate whether the duration of mediastinal drainage after cardiac surgery is associated with postoperative pain and opioid consumption in the early postoperative period.

### Materials and methods

The retrospective cohort study was performed according to the Helsinki Declaration and institutional review board approval was obtained. The analysis comprised 484 consecutive adult cardiac surgery patients treated at the Tampere University Heart Hospital, Tampere, Finland between December 2015 and August 2016. The study time period was determined by including each available consecutive patient when no interventional clinical trials were ongoing at the study program. The series included all elective, urgent, and emergency cardiac surgery performed at the institution through full sternotomy, including valve operations, coronary artery bypass grafting, surgery of the aortic root, ascending aorta or aortic arch, combined procedures, and redo operations. Preoperative patient demographics,

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medical history, procedural details, and the occurrence of complications, including clinically evident stroke confirmed by imaging studies and neurological assessment, new-onset atrial fibrillation with a duration of at least five minutes, need for reoperation for any cause, postoperative infections, and perioperative myocardial infarction determined by two of the following criteria: electrocardiographic changes indicating myocardial damage, new regional cardiac wall motion abnormalities, and/or significant elevation of serum cardiac biomarkers (creatine kinase isoenzyme MB activity over three times the upper limit of the reference range), were recorded. Postoperative infections were classified as deep sternal wound infections when concomitant sternal infection and need for surgical treatment was present, and other infections, such as pneumonia, when clinically evident and requiring specific treatment, for example antibiotics.

Two 24Fr mediastinal chest tubes – routinely Argyle Thoracic Catheter, Covidien, though Blake Silicone Drain, Ethicon, was also available – were inserted through the midline, inferior to the xiphoid process, at the end of each procedure in all patients. The first chest tube was placed substernally and the second usually in the pericardial well but occasionally posterior to the sternum if interference with coronary bypass grafts was suspected. Similar sized chest tubes were used for pleural drainage, if needed. All chest tubes were connected to a single vacuum system set at 10 H<sub>2</sub>Ocm suction level over the study period. Until and including the 10th of April 2016, the mediastinal chest tubes were routinely removed on the morning of the first postoperative day. These patients formed the short drainage group. With the goal of reducing the substantial incidence of late postoperative tamponade at the study institution, mediastinal drainage was thereafter continued until the second postoperative day in the extended drainage group [5,6]. In the presence of significant bleeding, drainage was continued until chest tube removal was considered safe in both groups.

Pain assessment was performed at least every two hours in the intensive care unit and a minimum of three times a day in the surgical ward using the numeric rating scale (NRS) or the visual rating scale (VRS). For postoperative pain management, all patients received routine peroral paracetamol 1g three times a day, as well as oxycodone hydrochloride, in both sustained-release and immediate-release forms, with individually adjusted doses aiming at no or minimal pain, guided by the NRS and VRS scores as well as the clinical judgement of physicians and trained nurses. Immediate-release form oxycodone was administered mainly perorally, but occasionally also intravenously or intramuscularly when needed. For some patients, sustained form oxycodone with naloxone hydrochloride was chosen. The main outcomes for the study were the amount of postoperative pain according to the pain scales and the number of opioid analgesics required for its management during the first five postoperative days, which were compared between the cohorts and patient subgroups. As the present study was a retrospective analysis and included patient material from an earlier study addressing the associations of mediastinal drainage and late pericardial tamponade [6], no separate power analysis was performed for this study.

In the statistical analyses, patients who did not survive the first five days ( $n = 14$ ) and those patients who received patient-controlled analgesia ( $n = 2$ ) were excluded. The mean NRS and/or VRS for each day was used. Statistical analyses were performed using SPSS for Windows version 16.0. Associations between patient and procedure-related characteristics and postoperative pain scores as well as opioid use during the first five postoperative days were ascertained. Univariable analyses were performed using the Chi-square and Fisher's Exact test for categorical variables and the Mann-Whitney  $U$ -test for non-parametric scale variables. Factors with statistically significant associations with postoperative opioid use in the univariable analyses were subsequently entered into a multivariable Binary Logistic Regression analysis and the model was adjusted for those variables. Statistical significance was set at  $p < .05$ .

## Results

### Study population

A total of 468 patients survived the first five days and were included in the analyses (Table 1). The most common procedures performed were isolated coronary artery bypass operations followed by single valve surgeries. There were no statistically significant differences in the preoperative characteristics, type and urgency of surgery performed, or complication rates between patients treated according to the short and long drainage protocols. The major adverse outcomes in included patients comprised a stroke rate of 2.1%, deep sternal wound infection in 1.3%, and infectious complications in 8.5%, with no statistically significant differences between the groups.

### Mediastinal chest tube drainage

The median length of mediastinal drainage was one (range 0–10, interquartile range 0–2) day in patients treated according to the short drainage protocol and two (range 1–10, interquartile range 1–3) days in patients treated according to the extended drainage protocol,  $p < .001$ . The duration of mediastinal drainage exceeded two days in 14.7% vs. 37.5% of patients treated according to the short vs. extended drainage protocols, respectively,  $p < .001$ . The median length of hospitalization before hospital discharge or referral was six days in patients treated according to the short drainage protocol and five days in those treated according to the extended drainage protocol,  $p = .065$ .

### Postoperative pain and opioid consumption

The overall opioid consumption and daily pain scores of the study patients are presented in Table 2. There were no differences in opioid use between the study groups (Figure 1). In univariable analysis, male sex, smoking, and aortic surgery were associated with higher, and advanced age, hypertension, peripheral vascular disease, as well as combined cardiac valve and coronary procedures with lower

**Table 1.** Study population.

	All patients	Extended drainage	Short drainage	p-Value
Number	468	216	252	
Male sex	69%	69%	69%	.902
Median age	70	68	70	.253
Elective surgery	68%	67%	69%	.647
Dyslipidemia	54%	56%	52%	.492
Hypertension	65%	68%	63%	.353
Diabetes	23%	23%	24%	.774
Coronary disease	50%	52%	49%	.568
NYHA 3–4	49%	52%	46%	.244
Peripheral vascular disease	7.3%	7%	7%	.912
Chronic lung disease	6%	6%	6%	.976
Median EF	60%	58%	60%	.889
Median BMI kg/m <sup>2</sup>	28	27	28	.297
Preoperative Creatinine μmol/L	81	80	82	.070
Smoking	13%	10%	15%	.114
Coronary surgery	34.8%	37%	33%	.463
Single valve surgery	31%	31%	31%	.902
Multiple valve surgery	4.9%	4.6%	5.2%	.792
Coronary and valve surgery	11%	11%	12%	.669
Aortic surgery	16%	15%	17%	.683

NYHA: New York Heart Association classification; EF: ejection fraction; BMI: body mass index.

**Table 2.** The median cumulative opioid use and the mean daily pain scale scores of study patients during the first five postoperative days according to the drainage protocol and patient and procedure characteristics.

	Median cumulative opioid use for the first five postoperative days			Mean daily pain scales				
	Short-acting opioids	Long-acting opioids	All opioids	D1	D2	D3	D4	D5
All patients	51	90	138	3.3	2.5	2.0	2.0	2.0
Short drainage	49	90	137	3.4	2.6	2.1	2.3	2.0
Extended drainage	52	90	140	3.4	2.6	1.9	2.0	2.1
Male sex	53*	100***	170***	3.1	2.3	2.0	2.0	2.0
Age ≥ 70	45***	50***	109***	3.0	2.2	2.0	2.0	2.0
Elective	46***	90*	133	3.4	2.5	2.0	2.0	2.0
EF < 50%	54	70*	137	3.0*	2.0	2.0	2.0	1.5
BMI ≥ 27kg/m <sup>2</sup>	51	90	152	3.0	2.5	2.0	2.0	2.0
NYHA 3–4	57***	80***	135	3.3	2.5	2.0	2.0	1.8
Smoking	54	100*	179*	4.0	2.0	2.0	2.0	2.0
Hypertension	48	80*	130*	3.0	2.5	2.0	2.0	2.0
Diabetes	42	90	138	3.0*	2.0	2.0	2.0	2.0
Coronary disease	50	83*	134	3.0	2.3	2.0	2.0	2.0
Peripheral vascular disease	52	60***	104**	2.0*	1.5**	2.0	2.0	2.3
Chronic lung disease	47	90	141	3.3	3.0	2.5	2.0	2.0
Dyslipidemia	50	90	136	3.0	2.5	2.0	2.0	2.0
Coronary surgery	48	90	139	3.0	2.4	2.0	2.0	2.0
Single valve surgery	48	95	132	4.0	2.5	1.7	2.0	2.0
Multiple valve surgery	52	70	127	2.3	2.7	2.0	2.0	3.0
Coronary and valve surgery	48	60**	123*	3.0	2.0	1.9	1.7	2.0
Aortic surgery	59*	100	185**	3.5	2.4	1.5	2.0	1.5

Note. Univariable statistical comparisons were performed between opposing subgroups, for example between those treated according to the short or extended drainage protocols, between males and females, and between smokers and non-smokers. Patient characteristics with statistically significant differences between opposing subgroups are given in bold.

\* $p < .05$ ; \*\* $p < .01$ ; \*\*\* $p < .001$ .

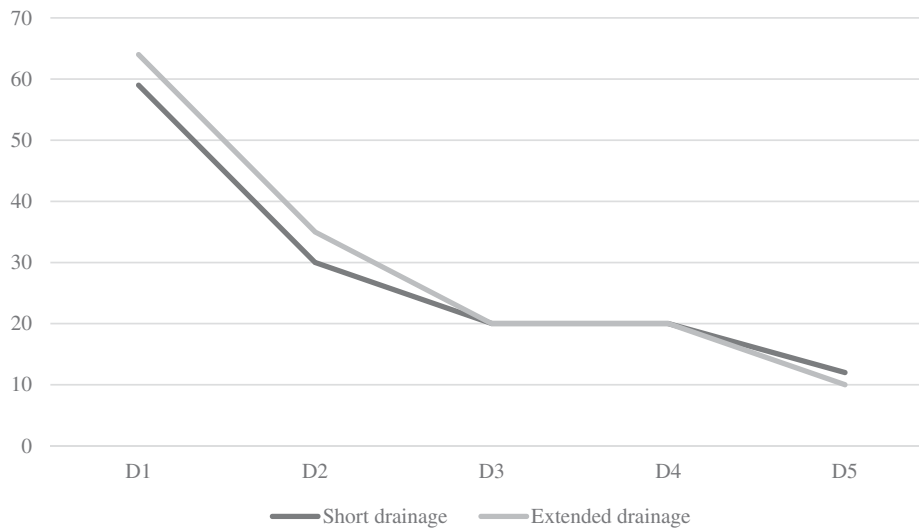
EF: ejection fraction; BMI: body mass index; NYHA: New York Heart Association classification.

cumulative opioid use during the first five days. The reported pain scores were similar between the study groups, but patients with reduced ejection fraction, obesity, and peripheral vascular disease reported somewhat lower pain scores initially. In multivariable analysis (Table 3), the duration of mediastinal drainage was not associated with the level of opioid use, while male sex and aortic surgery were statistically significantly associated with higher and advanced age with lower consumption.

## Discussion

The present study sought to analyze the role of mediastinal chest tube drainage on postoperative pain, and the authors

report that extended mediastinal drainage did not appear to be associated with increased postoperative opioid consumption or the NRS/VRS scores of cardiac surgery patients. The associations of short and extended pericardial drainage with the occurrence of late cardiac tamponade and bleeding in the same patient material have been explored in a separate paper (6). Modern multimodal analgesia is based on combining several methods of pain management with different mechanisms of action, with the aim of achieving synergistic benefit and reduction of adverse effects. Most commonly used methods entail paracetamol, opioids, and nerve blocks. As opioids frequently cause adverse effects, complementary means for treating postoperative pain are warranted and, partly to that end, a number of ultrasound-guided truncal



**Figure 1.** The median daily oxycodone consumption in milligrams according to the drainage protocol.

**Table 3.** Multivariable analysis.

	OR	95% confidence interval	<i>p</i>
Extended drainage	0.97	0.64–1.48	.897
Age $\geq$ 70	0.24	0.16–0.37	<.001
Male sex	3.33	2.1–5.29	<.001
Hypertension	0.78	0.5–1.22	.281
Smoking	1.66	0.85–3.26	.138
Peripheral vascular disease	0.59	0.26–1.34	.207
Coronary and valve surgery	0.71	0.37–1.38	.311
Aortic surgery	2.35	1.29–4.26	.005

Note. Odds ratios are calculated for cumulative opioid consumption of  $\geq$ 140mg during the first five postoperative days. The multivariable Logistic Regression model was adjusted for variables with statistically significant associations with the total opioid consumption in the univariable analyses.

nerve blocks targeting intercostal nerves at different anatomical sites have been presented in the recent literature.[2,7–9]

In a single randomized study including a limited number of patients, longer drainage with silastic tubes did not increase the reported pain scores when compared to shorter drainage with traditional chest tubes, but the study did not control for the use of opioids or other analgesics, which is imperative when considering the impact on postoperative pain [10]. In the present study, the daily opioid consumption was greatest on the first postoperative day, while earlier the peak opioid use has been reported to occur on the second postoperative day. The variance may be explained by differences in patient characteristics such as age and the perioperative care of patients between studies. Most patients required little or no opioids on the fifth postoperative day, concurring with earlier literature [11].

While pain is a subjective experience, the NRS and VRS scores are widely validated tools for its assessment [12]. The early pain scores reported in the present study were lower than previously described but cultural differences may limit the feasibility of comparing pain scores between studies and populations [13]. Patients with reduced ejection fraction, diabetes, and peripheral vascular disease reported somewhat lower pain scores initially. This finding might reflect habituation for discomfort and a higher prevalence of peripheral neuropathy in more morbid patients.

The postoperative consumption of opioids appeared higher in males, smokers, and after aortic surgery. It seems plausible that the increased need for opioids in men was at least partly related to the fact that males are generally larger and have a significantly higher lean body mass than females. The mean reported pain scores did not differ between males and females. Previously, in some but not all studies, female sex has been reported as a predictor of poor pain control, though mostly following non-cardiac surgery. Smoking is associated with younger age and male sex but has also been described as an independent predictor of dissatisfactory pain control through unclear mechanisms. Concurrent depression which has been linked to inadequate pain control may be more prevalent in smokers. Furthermore, smoking may be particularly consequential in causing postoperative pain following cardiac surgery as increased amounts of pulmonary secretions and consequent coughing may significantly aggravate sternotomy-related pain and even cause sternal dehiscence. In addition, acute smoking cessation has been reported to increase postoperative opioid consumption following coronary bypass grafting [14–17]. Aortic surgery frequently involves younger patients, males, and extensive procedures, probably explaining the result. There are several possible reasons for the lower opioid consumption observed in older and more morbid patients. Opioid-related adverse effects are probably more prevalent in them and may have limited their use, these patients may better tolerate pain and discomfort, and neuropathy may even be beneficial with regards to experiencing postoperative pain in contrast to younger and healthier patients. In addition, these patients were not as likely subjected to extensive and prophylactic procedures than younger and healthier persons and mostly underwent isolated simple procedures. It is unclear why patients treated according to the short drainage protocol required a longer hospitalization. It seems plausible that residual pericardial effusions necessitating follow-up were more frequent in these patients, but the finding may also have been coincidental.

The most important limitations of the study were its retrospective, non-randomized single-center setting and the

use of historical controls, due to which some caution is warranted in the interpretation of the results. Though similar chest tubes were used in each patient, the study population was heterogeneous, which is a possible source of bias. Other programs might routinely apply a different number or differently sized chest tubes. There were probably slight differences in the perioperative anesthesia management between patients that were not controlled for and may have been relevant [18]. Opioid consumption and pain scores incompletely describe the subjective postoperative discomfort of patients and other facets, such as nausea, fatigue, and confusion, maybe equally important and should be included in later studies. Unfortunately, the preoperative use of opioids and antidepressants was not recorded and their possible associations with postoperative pain could not be analyzed. However, the proportions of patients with these medications are unlikely to differ between the study groups. Concurrent pleural drainage was not controlled for. A significant strength of the study was the consideration of both pain and opioid consumption when earlier series with similar aims did not control for the pain medication [19]. Whether mediastinal chest tube drainage is associated with significant pain is relevant information for all cardiac surgery programs, since chest tubes are universally used on all patients postoperatively regardless of other potential differences in patient material, treatment protocols, and/or pain management between different programs.

In conclusion, the length of mediastinal chest tube drainage does not seem to be associated with the amount of postoperative pain or the need for opioid analgesics after cardiac surgery. Early pain scores were lower in patients with reduced ejection fraction, diabetes, and peripheral vascular disease. Male sex and aortic surgery were independently associated with higher and advanced age with lower overall opioid consumption.

## Disclosure statement

No potential conflict of interest was reported by the author(s).

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