Comparison of pain in the early post-operative period using VAS score in patients after cardiac surgery who had minimally invasive incisions vs. full median sternotomy

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OBJECTIVE: *Postoperative pain after open heart surgery is one of the most important factors affecting postoperative morbidity*[1]. *Interventions for anterior right thoracotomy for the treatment of atrial septal defects (ASD), and on mitral and tricuspid valves were used in the 1970s* [2]. *Currently, minimally invasive surgery is increasingly used in cardiac surgery in recent years because it offers a cosmetic advantage with an incision line under the breast and guarantees easy exposure* [2]. *As is known, exposure with mini sternotomy or with mini thoracotomy is frequently used, causing less damage to tissues, although sometimes it is technically difficult to obtain the desired exposure without increasing the opening of the retractor to improve the viewing angle. This causes tissue tension or bone fracture, with aggravation of postoperative pain and lengthening of convalescence.*
METHODS: *We used the visual analogue scale (VAS) for postoperative pain assessment among 15 patients who underwent minimally invasive surgery compared to 15 who underwent total median sternotomy in 2017, to compare the outcome in postoperative pain between the two groups. Our initial measurements were performed in the intensive care unit within the first 6 hours after* early *extubation. on the third day post-operative, at discharge and in the first week after. The start of postoperative exercises (respiratory exercises, mobilization), their efficiency, the extent of drainage, the extubation time and the duration of the intensive care stay were also recorded.*
RESULTS*: After an initial slight increase in scores in patients undergoing minimally invasive cardiac surgery in the first period, a general state of well-being, comfortable mobilization and greater success in postoperative exercises were observed starting from the 1st postoperative day. With respect to conventional surgery, discharge was more precocious, lower pain and improved signs of well-being during the postoperative follow-up of the first week.*
CONCLUSION: *Despite the limitation due to the limited number of patients studied, we believe that future studies conducted with larger patient groups would further support our findings.*

KEY WORDS: Minimally invasive cardiac surgery, Pain, Mini thoracotomy, mini sternotomy, VAS Score

Introduction

Pain is the main complaint that surgery patients have in the days and weeks following surgery. Post-operative pain is an acute pain that begins with surgical trauma, gradually diminishes and ends with tissue healing. According to the International Association for the Study of Pain (IASP, 1979), pain is defined as "an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage" and "a protection mechanism" [3,4].
There are many factors that affect postoperative pain. These include: The physiological and psychological condition of the patient, obesity, anxiety, young age, preparation of the patient in the preoperative period, psy-

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chological and pharmacological preparation of the patient in the postoperative period, type, location and duration of the surgery, postoperative complications, anesthetic techniques applied in the preoperative and postoperative period, nature and quality of the postoperative period[3,4,9,10,15].

It should also be noted that although the most reliable indicator of pain evaluation is the patient's own expression of pain, situations involving barriers to pain assessment may arise such as is the case when patients cannot describe or have difficulties in describing their own pain. Various comprehensive approaches are used to assess the level of pain. These include the quality and severity of the pain, its chronicity, contributing/associated factors, location/distribution, mode of injury and etiology.

Pain measurements can be performed by "Direct Measurement" and "Indirect Measurement". Direct measurements are aimed at revealing the nature of the pain. Indirect measurements measure the effect of pain on the quality of life [5].

Another classification for pain measurements is classification as "Unidimensional Measurement" and "Multidimensional Measurement". LANSS (Leeds Assessment of Neuropathic Symptoms and Signs) Scale, Visual Analogue Scale (VAS), Numerical Rating Scale (NRS) and Verbal Rating Scale (VRS) are examples of unidimensional scales. Examples of multidimensional scales are the McGill Pain Questionnaire (MPQ), the Quality of Life Assessment and the Patient Diary [5].

VAS (Visual Analog Scale) is commonly used especially in the evaluation of postoperative pain and is easy to understand and apply. Visual Analogue Scale (VAS) is a reliable and valid pain measurement method for evaluating the severity of acute and chronic pain [6,7]. The scale consists of a horizontal line with a length of 10 cm. For pain severity according to VAS, "no pain" is generally rated as 0 points and "the worst imaginable pain" is rated as 10 points (10 cm scale) [8]. The patient is told to mark a point on the line that will reflect his pain correctly. The distance of the patient's mark to the left end is measured. This distance, which is usually measured in millimeters, is reported as "points." The reliability and sensitivity of analogue scales have long been established in pain studies [10,13].

Pathophysiological Responses

Acute pain causes a wide range of pathophysiological responses, which are initiated when nociceptors are activated after tissue injury, resulting in a local inflammatory response [14]. After tissue injury, sympathoneural and neuroendocrine activation (along with uncontrolled pain) can ultimately lead to various potentially detrimental responses such as tachycardia, hypertension, hyperglycaemia, immunsuppression, decreased regional blood flow or venous stasis, and platelet aggregation [14].

Methods

15 patients who underwent open-heart surgery by conventional sternotomy and 15 patients who underwent open-heart surgery with minimally invasive incisions (mini-sternotomy, right anterolateral mini-thoracotomy)

TABLE I - *Operative and postoperative data of patients who underwent minimally invasive surgery.*

Patients	Minimally invasive	Age/Gender	Procedure	ICU (Day)	Hospital (Day)	Drainage(ml)	CCT(Min)
1		46/M	AVR (MS)	1	4	400	84
2		74/M	AVR(MS)	1	5	500	80
3		65/M	CABG2(MS)	1	5	550	34
4		70/M	CABG2(MS)	1	5	600	36
5		54/M	CABG1(MS)	1	4	450	BH
6		84/M	CABG1(MS)	1	5	500	BH
7		56/F	MVR(MT)	2	6	350	66
8		33/M	ASD(MT)	1	4	200	24
9		30/F	MVR(MT)	1	5	450	69
10		18/M	MVR(MT)	2	6	500	69
11		60/M	CABG2(BH)	2	5	500	BH
12		30/F	ASD(MT)	1	4	300	26
13		26/F	ASD(MT)	1	4	350	20
14		55/F	MVR(MT)	1	5	450	60
15		68/F	MVR(MT)	2	6	500	70
Mean		51.2		1.26	4.9	440	53.1

AVR: Aortic valve replacement, ASD: Atrial septal defect, BH:Beating Heart CABG: Coronary artery bypass grafting, CCT: Cross-clamp time, CPBT: Cardiopulmonary bypass time, ICU: Intensive Care Unit, MVR: Mitral valve replacement, MS: Mini-sternotomy, MT: Right anterolateral mini-thoracotomy.

TABLE II - *Operative and postoperative data of patients who underwent full median sternotomy.*

Patients Conventional sternotomy	Age/Gender	Procedure	ICU (Day)	Hospital (Day)	Drainage(ml)	CCT(Min)
1	74/M	CABG3	2	7	800	32
2	63/M	CABG3+CE	3	8	900	28
3	54/M	CABG3	2	7	700	33
4	64/M	CABG4	2	7	800	34
5	42/M	CABG4	2	7	750	36
6	61/F	MVR	3	8	650	51
7	55/M	CABG4	2	7	800	38
8	55/F	CABG4	3	8	900	45
9	66/F	CABG2 BH	2	8	700	BH
10	62/M	CABG4	2	7	700	38
11	70/M	CABG4	3	7	700	36
12	63/M	CABG3	2	7	600	32
13	72/F	MVR+AVR	3	8	600	70
14	68/M	MVR+T. De Vega	2	8	500	50
15	74/M	MVR	2	7	500	40
Mean	67.7		2.38	7.4	610	40.21

CE: Carotis Endarterectomy Aortic valve replacement, BH: Beating Heart, CABG: Coronary artery bypass grafting, CCT: Cross-clamp time, ICU: Intensive Care Unit, MVR: Mitral valve replacement.

at Hisar Intercontinental Hospital between March-November 2017 were followed up postoperatively. We compared their drainage amounts, extubation time, intensive care hospitalization times, and need for inotropic support over a period of more than 24 hours, as well as post-operative incision site pain by VAS method. The pain index test was performed on post-op Day 3, discharge day, and at the first follow-up during the post-operative week 1 after discharge. The pain index was calculated by multiplying the severity of pain and the frequency of pain using VAS scoring. Patients in both groups after operation, received standard care medications that included opioid pain relievers (single dose of 100 mg Tramadol HCL in 2ml solution ampule given I.V. on the first evening post-op), NSAIDs (diclofenac sodium 75 mg tablets given twice a day post-op) and paracetamol (1gr, I.V. twice a day for the first three days). The patients were sedated with pentanyl (500 mcg/10 ml ampule, I.V.), rocuronium bromide (50 mcg/5 ml ampule, I.V.), midazolam (5 mg/5 ml ampule, I.V.) and propofol 500 mg/50 ml ampule, I.V.). After the cross clamp was removed, an infusion of perlinganite (nitroglycerine 10 mg/10 ml ampule, I.V., 5 mcg/kg/hr) and dexmedetomidine (200 mcg/2ml ampule I.V., 0.5 mcg/kg/hr infusion) was started. In the intensive care unit, the dose was gradually decreased and all patients were extubated early (first 6 hours). On the first night, VAS scoring was performed on all patients. The patients were questioned about the severity and frequency of pain. They were asked to grade the severity of pain from 1 to 10. The patients' start of post-operative exercises (respiratory exercises, mobilization) and their performances were also recorded. VAS scoring was performed by Dr. Kenan Kara, M.D.

15 patients underwent open heart surgery with minimally invasive approaches between March-November 2017. Median age was 51.2 years (18-84 years). Six of them were female (40%). J Mini-sternotomy was performed for 2 patients who underwent aortic valve replacement (AVR). 2 patients underwent CABG beating heart via T sternotomy (CABG1). Another 3 patients underwent CABG with LAD-RCA and LAD-D1 (CABG2). 8 patients' operations were done via right anterolateral minithoracotomy (MT). Five patients underwent mitral valve replacement (MVR), Three patients underwent ASD repair (Table I).

Another 15 patients underwent open heart surgery with routine full median sternotomy between March-November 2017. Median age was 67.7 years (42-74 years). Four of them were female (26%). Eleven patients underwent CABG. Carotid endarterectomy was performed in one of the patients who underwent CABG. 1 patient underwent Beating Heart CABG. Mitral valve replacement (MVR) was performed in 4 patients (Table II).

SURGICAL TECHNIQUES FOR MINIMALLY INVASIVE GROUP

In the upper mini-sternotomy group for AVR, an approximately 6-8 cm long midline skin incision was made starting from the suprasternal notch. A superior J shaped mini-sternotomy was performed by dividing the sternum using an oscillating saw down to the fourth intercostal space and transecting obliquely to the right or left (J shape) or both (T shape). An inferior J- or T-shaped incision was made in the CABG group. LIMA was harvested for all CABG patients. The skin incision was 6-8 cm long.

Arterial cannulation was performed using a conventional technique in the distal part of the ascending aorta. For patients undergoing AVR and CABG, venous cannulation was performed in the right atrium. Cross-clamping and cardioplegia applications were done via ascending aorta. A 36Fr or 32Fr drainage tube was placed in the mediastinal cavity and left thorax.

In the anterolateral minithoracotomy group, right anterior minithoracotomy was performed by marking a 7-10 cm incision for patients undergoing MVR and ASD. Conventional technique was used for cannulation in all patients except in one patient undergoing MVR, where right femoral vein cannulation was performed because of poor exposure from the thoracotomy incision. Additionally, for two patients, beating heart CABG was performed. All surgeries were performed using the same anesthesia protocol, moderate hypothermic CPB (30-32 °C), and isothermal blood cardioplegia.

All patients were extubated in the ICU, 4-6 hrs after surgery. No cases of wound complication and re-hospitalization for wound care were noted.

Post-Operative Physical Therapy Management

All patients received 3 to 6 physical therapy treatment sessions per day for 5 days. These treatments included breathing and mobilization exercises (as well as coughing support and chest wall vibrations). Results for post op days 1 and 5 for each patient are included in Tables 4 and 6. A 3-tiered grading system was used to assess performances during each session towards a specific goal and assign grades correlating to level of achievement. These grades were then averaged for each day and tabulated.

1 of 3 grades were assigned as follows: For mobilization exercises, + for patients who were able to stand up during the first day, ++ for patients able to walk 5 meters, and +++ for patients able to walk 20 meters. For respiratory exercises, a Triflo II 3-ball incentive spirometer (Tyco Healthcare, USA) was used to evaluate the maximal breathing capacity of each patient through repeated inspiratory effort (10 to 15 breaths) within approximately a 3-minute timeframe. Patients were asked to inhale thoroughly as to generate sufficient inspiratory effort to lift as many balls as possible to the top of their respective columns (I, II, III). Flow rates of 600 ml/sec were required to lift the first ball in column I, 900 ml/sec to lift both balls in columns I and II, and 1200 ml/sec to lift all three balls in columns I, II, and III. Patients were assigned grades of + for achieving steady flowrates of 600 ml/sec , ++ for steady flowrates of 900 ml/sec, and +++ for steady flowrates of 1200 ml/sec.

Statistical Analysis

No *statistical* tests were used. Data were expressed as mean ± standard deviation.

Results

In the minimally invasive group, the mean cross clamp time was 53.1 mins. All patients were extubated in the ICU within 4-6 hours after surgery. In the conventional group, the mean cross clamp time was 40.2 mins. The longer cross clamp time in the minimally invasive group was due to the complexity of the surgical techniques associated with minimally invasive surgery which

Table III - *Postoperative data for patients who underwent minimally invasive surgery*

Patients Post-extubation	Pain index pain index	Pain index on post-op day 3	Pain Index on the day of discharge	at follow-up week 1
1	42	20	4	0
2	50	24	8	1
3	42	20	6	1
4	45	28	6	3
5	42	28	4	3
6	30	16	4	0
7	48	28	8	4
8	40	18	6	1
9	50	30	10	4
10	42	12	6	0
11	50	20	4	0
12	49	16	6	1
13	36	28	8	2
14	35	24	8	3
15	42	30	6	2
Mean	42.5	23.4	6.36	1.94

Pain index: Severity of pain x frequency of pain

TABLE IV - *Respiratory and Mobilization exercise performance data for patients who underwent minimally invasive surgery*

Patients Minimally invasive	Post op 1 performance respiratory exercises	Post op 1 performance mobilization exercises	Post op 5 performance respiratory exercises	post op 5 performance mobilization exercises
1	++	++	+++	+++
2	+	++	+++	+++
3	+	++	+++	+++
4	++	++	+++	+++
5	+	++	+++	+++
6	++	+++	+++	+++
7	++	++	+++	+++
8	++	++	+++	+++
9	++	+++	+++	+++
10	++	+++	+++	+++
11	++	+++	+++	+++
12	+	++	+++	++
13	+	++	+++	+++
14	+	++	+++	+++
15	++	++	+++	+++

TABLE V - *Postoperative data for patients who underwent full median sternotomy*

Patients conventional sternotomy	Post-extubation pain index	Pain Index on post-op day 3	Pain Index on the day of discharge	Pain Index at follow-up week 1
1	36	24	12	6
2	40	18	10	6
3	36	15	8	4
4	40	20	10	6
5	42	24	12	8
6	35	20	10	6
7	36	24	10	6
8	24	18	8	4
9	32	24	16	10
10	20	18	8	4
11	50	30	10	8
12	40	24	14	4
13	36	28	6	3
14	32	24	16	8
15	28	30	12	6
Mean	36.6	26	11.4	5.8

Pain index: Severity of pain x frequency of pain

TABLE VI - *Respiratory and mobilization exercise performance data for patients who underwent full median sternotomy*

Patients conventional sternotomy	Post-op 1 performance respiratory exercises	Post op 1 performance mobilization exercises	Post op 5 performance respiratory exercises	Post op 5 performance mobilization exercises
1	+	+	+++	+++
2	+	+	++	++
3	+	++	++	+++
4	+	+	++	++
5	++	+	+++	+++
6	++	++	+++	+++
7	+	++	++	++
8	++	++	+++	+++
9	++	++	++	+++
10	++	++	+++	+++
11	++	++	++	++
12	+	+	++	++
13	+	+	+++	+++
14	++	++	+++	+++
15	+	++	++	+++

are regarded as requiring more skill. However, we believe that this prolonged cross clamp time can be shortened in the future as more experience is gained through each additional case. The drainage amount in the minimally invasive group was 440 ml, while in the conventional group it was 610 ml.

Patients' duration of stay in the intensive care unit was 1.26 days in the minimally invasive group whereas it increased to 2.38 days in operations performed with full median sternotomy. When the days to discharge were examined, the patients who underwent minimally invasive techniques were discharged within 4.9 days on average, while the patients in the full median sternotomy group were discharged within 7.4 days. We did not see any wound complications in either group. When the pain scores were examined, although the pain index was higher in patients in the minimally invasive group in the early stage (42.3 vs. 36.6), there was a noticeable decrease in pain and improved well-being in their follow-up on subsequent days and in the first week following discharge (1.94 vs. 5.8) (Tables III, V).

The mini-thoracotomy procedure predisposes the thoracic nerve to perioperative injury which may explain this initial increase in early post-operative pain. Additionally, minimal access J or T shape sternotomies involve the dividing of the sternum by way of two surgical incisions, one vertical and another horizontal, as compared to only a single incision in full median sternotomy, consequently resulting in more pain in the early postoperative period.

The patients in the minimally invasive group performed considerably better during their postoperative physical therapy sessions. Patients in this group started their breathing exercises earlier and were able to demonstrate improved mobility (Tables IV, VI).

Discussion

After cardiac operations, patients experience incisional pain associated with sternotomy, chest tube insertion, and saphenous vein harvesting from the leg [16]. Post-operative pain appeared to decrease day by day over the postoperative first week. However, patients still experienced sleep disruptions and excessive daytime sleepiness [23]. Postoperative pain can be the cause of a number of adverse sequelae such as myocardial ischemia, respiratory insufficiency, and thromboembolic complications [17-19]. Opioids and nonsteroidal antiinflammatory drugs (NSAIDs) are administered parenterally as analgesics in the early postoperative period to alleviate such pain [20]. However, the efficacy of these analgesic drugs is limited by side effects that impede patient rehabilitation after surgical intervention. Pain may progress to side effects (GIS bleeding, renal dysfunction, bleeding due to platelet inhibition) often associated with the frequent use of pain relievers and even opioid addiction. Opioids, such as morphine, may be associated, with respiratory depression, excessive sedation, biliary spasm, depression of gastrointestinal motility, nausea and vomiting [21,22].

It is very difficult to perform VAS scoring in patients who are intubated in the ICU after cardiac surgery. Intubated patients have difficulty expressing themselves even if they are awake, and thus the sensation of pain in this early period may not be accurately scored. Also, insomnia is common in patients in the early days, often due to iatrogenic sleep disruptions. Major reasons for waking patients are to perform assessments, medication administration and laboratory tests. Frequent wake-ups in the intensive care unit at midnight due to medication cause them to experience doze-offs within the next day. The accompanying pain, anxiety and confusion are highly catastrophic particularly in elderly patients considering their predisposition to depression.

Conclusion

To minimize complications arising from pain, physicians must first address the underlying causes of pain. Our data clearly demonstrates that the postoperative comfort of patients is increased, and reporting of pain minimized, following minimally invasive surgery. This is evidenced by our findings showing that the frequency and severity of pain being reported is less, and the patients can be fast-track extubated and communicated with sooner within the early hours. This allows patients to resume routine daily life early in the post-operative period. In especially elderly, obese, diabetic patients, pain and wound healing problems following cardiac surgery lead to prolonged duration of hospitalization or early readmission to the hospital. This causes both a decreased quality of life for the patient and significantly higher hospital expenses. We believe minimally invasive cardiac surgery provides for better quality care as it addresses many of these problems by effectively reducing complications, shortening the total convalescent period, and potentially increasing overall patient quality of life.

Riassunto

Il dolore post-operatorio dopo chirurgia a cuore aperto è uno dei fattori più importanti che influenzano la morbilità. Postoperatoria [1].

Gli interventi per toracotomia anteriore destra per il trattamento dei difetti del setto atriale (ASD), e sulle valvole mitrali e tricuspidi sono stati utilizzati negli anni '70 [2]. Attualmente la chirurgia mini-invasiva è sempre più utilizzata in cardiochirurgia in questi ultimi anni perché offre un vantaggio cosmetico con una linea di incisione sotto il seno e garantisce una facile esposizione [2]. Come è noto, sono frequentemente utilizzate sia l'esposizione con mini sternotomia o con mini toracotomia,

provocando meno danni ai tessuti, anche se talvolta è tecnicamente difficile ottenere l'esposizione desiderata senza aumentare l'apertura del divaricatore per migliorare l'angolo di visione. Ciò provoca tensione dei tessuti o frattura delle ossa, con aggravamento del dolore postoperatorio e prolungamento della convalescenza.
Abbiamo utilizzato la scala analogica visiva (VAS) per la valutazione del dolore post-operatorio tra 15 pazienti sottoposti a chirurgia mini-invasiva rispetto a 15 sottoposti a sternotomia totale mediana nel 2017, per confrontare l'esito in quanto a dolore postoperatorio tra i due gruppi.
Le nostre misurazioni iniziali sono state eseguite nell'unità di terapia intensiva entro le prime 6 ore dopo l'estubazione precoce. nel terzo giorno post-operatorio, all'atto della dimissione e nella prima settimana successiva. Sono stati anche registrati l'inizio degli esercizi postoperatori (esercizi respiratori, mobilizzazione), la loro efficienza, l'entità del drenaggio, il tempo di estubazione e la durata del ricovero in terapia intensiva.
Dopo un iniziale lieve aumento dei punteggi nei pazienti sottoposti a chirurgia cardiaca minimamente invasiva nel primo periodo, è stato riscontrato uno stato di benessere generale, una mobilizzazione confortevole e un maggiore successo negli esercizi postoperatori a partire dal 1° giorno postoperatorio. Rispetto alla chirurgia convenzionale la dimissione è stata più precoce, il dolore inferiore e segni migliorati di benessere durante il follow-up post-operatorio della prima settimana.
Nonostante la limitazione dovuta al limitato numero di pazienti studiati, riteniamo che studi futuri condotti con gruppi di pazienti più ampi supporterebbero ulteriormente le nostre scoperte.

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