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SPECIFICS OF USING THORACIC BANDAGE AFTER CARDIAC SURGERY VIA STERNOTOMY AND ITS IMPACT ON REDUCING PAIN DURING THERAPEUTIC EXERCISES

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Цитування: Медичні перспективи. 2022. Т. 27, № 2. С. 71-76

Cited: Medicni perspektivi. 2022;27(2):71-76

Ключові слова: фізична терапія, стернальні застереження, кардіореабілітація, підтримуючі пристрої

Ключевые слова: физическая терапия, меры предосторожности в отношении грудины, кардиореабилитация, поддерживающие устройства

Key words: physical therapy, sternal precautions, cardiac rehabilitation, supportive devices

Abstract. Specifics of using thoracic bandage after cardiac surgery via sternotomy and its impact on reducing pain during therapeutic exercises. Vitomsky V.V., Vitomska M.V., Lazarieva O.B. Purpose: to investigate specifics of using thoracic bandage after cardiac surgery via sternotomy and its impact on reducing pain during therapeutic exercises. In order to study specifics of using a postoperative thoracic bandage on the seventh postoperative day patients (n=252) were asked two questions about the force of thorax compression exerted by the bandage. As soon as the questions were answered, the degree of thoracic bandage tension was also assessed by a physical therapist. Thereafter, some patients (n=44; who did not take painkillers within 12 hours before the examination) assessed pain on a numeric rating scale (10 points – maximum pain, 0 points – no pain) as follows: at rest, when coughing and moving their upper extremities (arms forward, sideward, upward), when wearing a bandage with and without a load (dumbbells 1 and 2 kg for each arm); then all points of the scale were assessed without wearing a thoracic bandage. Most of the patients noted that the bandage exerted light compression (184 patients) and did not restrict deep breathing (220 patients). The evaluation performed by a physical therapist found that a thoracic bandage had only a slight degree of tension in most of the patients (194 patients or 76.98%), since it was easy to slip the hand between the patient's back and the bandage, stretching the latter with minimal effort. The use of a thoracic bandage had no impact on the pain when patients moved their upper extremities. The obtained pain rates were very low. The highest pain rates were obtained during coughing. When moving arms the level of pain did not change statistically as compared with the state of rest. Arm position and load increase within specific limits had no impact on pain level. The use of a postoperative thoracic bandage is characterized by its mild tension, which does not limit deep breathing and, consequently, cannot limit the increase of chest circumference during dehiscence. The assessment of tension performed by physical therapists was consistent with the patients' responses. The use of a bandage did not reduce the level of pain when patients moved their upper extremities and coughed.

Реферат. Особливості використання торакального бандажа після операцій на серці зі стернотомією та його роль у зменшенні болю при виконанні терапевтичних вправ. Вітомський В.В., Вітомська М.В., Лазарева О.Б. Мета – дослідити особливості використання торакального бандажа після операцій на серці зі стернотомією та його роль у зменшенні болю при виконанні терапевтичних вправ. З метою дослідження особливостей використання післяопераційного торакального бандажа, на сьомий післяопераційний день пацієнтам (n=252) ставилися два запитання щодо сили стискання бандажем грудної клітки. Ступінь натягу торакального бандажа оцінювався також фізичним терапевтом після надання пацієнтом відповідей на запитання. Після цього частка пацієнтів (n=44; не приймали знеболюючих впродовж 12 годин до обстеження) брала участь в оцінці болю за числовою шкалою (10 балів – максимальний біль, 0 балів – біль відсутній) за таким алгоритмом: у стані спокою, при кашлі та при рухах верхніми кінцівками (руки вперед, у сторони, вгору) при

вдягнутому биндажу без та з навантаженням (гантелі 1 та 2 кг для кожної руки); повторення всіх пунктів оцінки без використання торакального биндажу. Більшість пацієнтів відзначила, що биндаж здійснює легке стискання (184 пацієнти) і не обмежує глибокий вдих (220 пацієнтів). Оцінювання, котре проводилося фізичним терапевтом, установило, що в більшості пацієнтів торакальний биндаж має лише легкий ступінь натягу (194 пацієнти, чи 76,98%), оскільки між спиною пацієнта та биндажем можна було легко просунути долоню й відповідно розтягнути биндаж з мінімальними зусиллями. Використання торакального биндажу не вплинуло на біль при виконанні рухів верхніми кінцівками. Отримані показники болю були дуже низькими. Найбільші показники отримано при виконанні кашлю. При виконанні рухів руками рівень болю статистично не змінювався порівняно зі станом спокою. Положення рук і збільшення навантаження у вказаних межах не впливало на рівень болю. Використання післяопераційного торакального биндажу характеризується легким ступенем його натягу, котрий не обмежує глибокий вдих і, відповідно, не зможе обмежити збільшення окружності грудної клітки при дегісценції. Оцінка сили натягу фізичними терапевтами узгоджувалася з відповідями пацієнтів. Використання биндажу не зменшило рівень болю при рухах верхніми кінцівками та кашлі.

Cardiac surgery (CS) via median sternotomy is a worldwide practice nowadays. After CS patients are provided with a number of recommendations on sternal precautions, restrictions on moving their upper extremities, loading, avoiding unilateral movements of the upper extremities, peculiarities of changes in body position, as well as prohibitions to lie on the side [10]. The available recommendations have significant variations [1]. Scientific studies confirm excessive and groundless nature of these restrictions and recommendations [1, 10], as well as the possibility of increasing the time required to return to work and prolonged hospital discharge when following such recommendations [5]. On the other hand, according to the studies, a significant number of daily activities cause a minimal load on the sternum [3, 4]. Comparison of standardized and alternative (less restrictive) recommendations did not reveal any negative impact on sternal healing and patients' complaints in a number of studies [1, 10].

The use of a thoracic bandage or spinal support also refers to measures aimed at reducing sternal complications during mobilization and motor activity of a patient within physical therapy programs after CS via sternotomy, but the mode of action of a thoracic bandage remains unconfirmed from the biomechanical perspective [19]. Regarding pain indicators when using external thoracic fixation, studies show decrease of pain on coughing on the 2nd and 3rd day after surgery [11], during coughing in patients with severe chest pain or signs of sternal instability [7]; the absence of impact on the level of pain [9, 13].

The lack of consistency regarding the role of sternum external fixation devices after sternotomy requires further study of the use of thoracic bandages and spinal supports in the postoperative period due to the possibility of their improper use by the patients, especially in terms of bandage tension.

The purpose of the research is to investigate specifics of using a thoracic bandage after cardiac surgery via sternotomy and its impact on reducing pain during therapeutic exercises.

MATERIALS AND METHODS OF RESEARCH

The study of the specifics of using a thoracic bandage after cardiac surgery via sternotomy involved 252 patients – group 1 (G1). The study of the impact of a thoracic bandage on reducing pain during therapeutic exercises involved 44 patients – group 2 (G2) (none of the patients took painkillers within 12 hours before the examination and long-acting painkillers within 48 hours before the examination). The study protocol was approved by the local medical ethics committee of SI "Scientific and Practical Medical Center for Pediatric Cardiology and Cardiac Surgery of the Ministry of Health of Ukraine" (protocol No. 1 of 21.01.2020, No. 1 of 12.01.2020). The research was performed in compliance with the basic provisions of the "Rules of ethical principles of scientific medical research with human participation", approved by the Declaration of Helsinki (1964-2013), ICH GCP (1996), EEC Directive No. 609 (dated 24.11.1986), orders of the Ministry of Health of Ukraine No. 690 dated 23.09.2009, No. 944 dated 14.12.2009, No. 616 dated 03.08.2012. All the patients were informed about the study protocol and gave a written informed agreement.

Intervention. All the patients followed the same protocol of early mobilization. Besides, the physical therapy program involved therapeutic exercises and methods of respiratory physical therapy. The key provisions of the physical therapy program are presented in the previous studies [16, 17, 18]. It should be noted that during the physical therapy, patients performed therapeutic exercises raising arms forward and sideward. A thoracic bandage was worn by all the patients starting from 1-2 postoperative days.

Data from the medical histories (examinations and studies according to the patient management protocol) [6] were analyzed to compare the groups of patients.

In order to study specifics of using a postoperative thoracic bandage on the seventh postoperative day patients (n=252) were asked two questions about the force of thorax compression exerted by the bandage and were provided with possible answers. As soon as the questions were

answered, the degree of thoracic bandage tension was also assessed by a physical therapist:

lack of tension – bandage was close to the chest and its length did not decrease when the bandage was opened;

mild tension – easy to slip the hand between the patient's back and the bandage, stretching the latter with minimal effort;

moderate tension – moderate effort to slip the hand between the patient's back and the bandage;

severe tension – severe effort to slip the hand between the patient's back and the bandage.

Thereafter, some patients (n=44) assessed pain on a numeric rating scale [12] (10 points – maximum pain, 0 points – no pain) as follows:

1. at rest with a bandage on;

2. when coughing with a bandage on;

3. when moving the upper extremities from the initial position arms downward, namely when raising the arms forward, sideward, and upward moving from the position arms forward with a bandage on;

4. performing item 3 with a load of 1 kg for each arm;

5. performing item 3 with a load of 2 kg for each arm;

6. performing items 1-5 without wearing a thoracic bandage.

Patients were asked to perform movements at medium / moderate speed.

The obtained results were processed by the methods of mathematical statistics [14]. The analysis

of correspondence of quantitative indicators distribution to the law of normal distribution was checked by Shapiro-Wilk test. Since the distribution of the vast majority of indicators did not correspond to normal, median (Me) and interquartile ranges (25%; 75%) were calculated for all indicators. Mean value and root-mean-square deviation ($M \pm SD$) were calculated for the results of indicators that corresponded to the law of normal distribution, and for pain indicators additionally. Wilcoxon test was used to compare the results of pain assessment with and without a bandage, as well as for other pairwise comparisons of dependent samples (e.g., pain assessment when moving with and without loading, comparison of pain when coughing and moving arms).

The data of the study were processed in STATISTICA 13.5.0.17 (TIBCO Software Inc, No. ZZS9990000099100363DEMO-L).

RESULTS AND DISCUSSION

Key preoperative time indicators of surgical interventions among the examined patients are presented in Table 1. G1 included 171 males (67.9%), and G2 included 32 (72.7%) males. $M \pm SD$ values for the body weight index comprised 29.31 ± 4.78 kg/m² in G1 and 30.4 ± 5.23 kg/m² in G2. $M \pm SD$ values in G2 for the body length index comprised 169.2 ± 8.5 cm, for the duration of cardiopulmonary bypass – 201.9 ± 63.4 minutes, for the duration of aortic compression – 140.3 ± 49 minutes.

Table 1

The key features of the groups (Me (25%; 75%))

Indicators	G1 (n=252)	G2 (n=44)
Age, years	63 (56; 69)	62 (51.5; 66)
Body weight, kg	83 (72; 93)	85 (72; 101)
Body length, cm	169 (161; 176)	170.5 (162.3; 175)
Body-weight index, kg/m ²	29 (26.9; 32)	29.7 (26.5; 34)
Ejection fraction of left ventricle, %	53 (45.3; 58)	55 (47.3; 59.8)
Operation duration, min.	375 (300; 435)	405 (333.75; 450)
Cardiopulmonary bypass duration, min.	180.5 (140.3; 226)	195.5 (145.3; 242.8)
Artificial lung ventilation duration, hour	8 (6; 11)	7.5 (5.25; 14)
Duration of anaesthesia, min.	437.5 (370; 510)	480 (412.5; 540)
Duration of aortic compression, min.	122 (95; 158)	138.5 (100.8; 182.8)
Duration of stay at the emergency department, nights	2 (2; 2)	2(2; 2)
Duration of stay in the postoperative ward, nights	7 (6; 9)	7(6; 9)

The first question asked concerned the force of thorax compression exerted by the bandage. Most of the patients reported that the bandage produced slight compression (184 patients or 73.02%). The smallest share of the patients noted that the bandage did not exert any compression (25 patients or 9.92%). 43 patients (17.06%) noted moderate compression, whereas none of the patients had severe compression.

The second question concerned restriction of a deep breath caused by a thoracic bandage. Most patients noted that the bandage did not restrict deep breathing (220 patients or 87.3%). A smaller proportion of patients noted that the bandage slightly restricted deep breathing (32 patients). Moderate and severe restriction of deep breathing was noted by none of the patients.

The assessment performed by a physical therapist revealed that thoracic bandage had mild tension in most of the patients (194 patients or 76.98%), since it was easy to slip the hand between the patient's back and the bandage, stretching the latter with minimal effort. Physical therapists did not reveal any tension of the bandage in other patients, since it was close to the chest and its length did not decrease when the

bandage was opened, or the bandage was not fixed and freely changed its position. Moderate and severe thoracic bandage tensions were not observed in any of the patients.

According to the results, the use of a postoperative thoracic bandage does not reduce pain when moving the upper extremities with a medium/moderate speed (Table 2). In G2 68.2% of patients note that the bandage performs slight compression, 31.8% – bandage does not compress; 86.4% – bandage does not restrict deep breathing, and 13.6% – bandage slightly restricts deep breathing; according to the physical therapist 95.5% had a mild degree of tension and 4.5% – lack of tension. The obtained pain rates were very low. The highest pain rates were obtained when coughing with the use of a bandage ($p < 0.001$) and without it ($p < 0.001$). When performing arm movements, the level of pain did not change statistically as compared with the state of rest. Particularly, there was no significant difference between the state of rest and raising arms upward with dumbbells (2 kg for one arm) when using a bandage ($Z = -1.852$; $p = 0,064$) and without it ($Z = -1.715$; $p = 0.086$).

Table 2

The results of pain assessment, scores (n=42)

Patient's condition / movement of the upper extremities	With a bandage		Without a bandage		Criterion	p*	
	Me (25%;75%)	M±SD	Me (25%;75%)	M±SD			
State of rest	0 (0; 0)	0.16±0.57	0 (0; 0)	0.16±0.57	0.000 ^b	1.000	
When coughing	2 (0; 4)	2.14±1.92	2 (0; 4)	2.2±2.05	-1.732 ^c	0.083	
Without a load	Arms forward	0 (0; 0)	0 (0; 0)	0.09±0.42	-1.000 ^d	0.317	
	Arms sideward	0 (0; 0)	0.25±0.87	0 (0; 0)	0.23±0.86	-1.000 ^d	0.317
	Arms upward	0 (0; 0)	0.23±0.52	0 (0; 0)	0.16±0.48	-1.732 ^d	0.083
With 1 kg load	Arms forward	0 (0; 0)	0.25±0.97	0 (0; 0)	0.18±0.76	-1.732 ^d	0.083
	Arms sideward	0 (0; 0)	0.3±0.93	0 (0; 0)	0.18±0.76	-1.890 ^d	0.059
	Arms upward	0 (0; 0)	0.32±0.74	0 (0; 0)	0.27±0.66	-1.414 ^d	0.157
With 2 kg load	Arms forward	0 (0; 0)	0.18±0.87	0 (0; 0)	0.18±0.87	0.000 ^b	1.000
	Arms sideward	0 (0; 0)	0.23±0.89	0 (0; 0)	0.2±0.76	-1.000 ^d	0.317
	Arms upward	0 (0; 0)	0.36±0.94	0 (0; 0)	0.34±0.86	-1.000 ^d	0.317

Notes: ^b – the sum of negative ranks corresponds to the sum of positive ones; ^c – negative ranks are used; ^d – positive ranks are used; * – to compare values with and without a bandage.

Pairwise comparison of pain indicators in all positions of the arms (forward – sideward; forward – upward; sideward – upward) did not reveal any statistical differences between the results ($p > 0.05$) both with the use of a bandage and without it, as well as

with all levels of loading. Therefore, the position of the arms had no impact on the level of pain.

Comparison of pain when moving without a load and with a maximum load (2 kg for one arm) did not show any statistical difference between the results

when raising the arms forward ($Z = -0.184$; $p = 0.854$), sideward ($Z = -0.577$; $p = 0.564$), and upward ($Z = -1.190$; $p = 0.234$) with the use of a thoracic bandage, and when raising the arms forward ($Z = -0.535$; $p = 0.593$), sideward ($Z = -0.577$; $p = 0.564$), and upward ($Z = -1.730$; $p = 0.084$) without using a thoracic bandage. Consequently, load increase within certain limits had no impact on the level of pain.

According to the obtained results, the tension of a thoracic bandage is insufficient to counteract sternal separation due to the necessary biomechanical conditions of its use, particularly regarding the restriction of a deep breath [19]. According to the patients' responses, the force of sternal compression exerted by the bandage mainly remained within comfortable limits. According to the analysis of patients' responses, most of them (73.02%) felt only light compression exerted by the thoracic bandage, which is consistent with the assessment of the physical therapists, who noted that a thoracic bandage had mild tension in most of the patients (78.2%).

Statistically higher levels of pain were obtained when coughing both with the use of a bandage ($p < 0.001$) and without it ($p < 0.001$), as compared with all other estimates of pain when moving the upper extremities and at rest. This is consistent with the data from the previous studies stating that coughing results in the greatest increase in sternal pain and micromotion [3]. Besides, this is consistent with the fact that Valsalva forces during cough are greater than when lifting 2.3 kg, lifting a 11.4 kg simulated child, a suitcase (13.6 kg), two weights (18.2 kg) or a gallon of milk (3.7 kg) [15].

At the same time, ultrasound findings show a slight motion of sternum halves after median sternotomy and standard wire closure during dynamic upper extremities and trunk tasks among cardiac surgery patients over the first three postoperative months, while coughing significantly increases separation of sternal edges in the lateral direction as compared to rest and all other tasks [2].

The comparison of pain indicators in all arm positions confirmed that the position of the arms did not affect the level of pain. These results are consistent with the conclusions of the previous studies.

For example, according to another study, compressing mechanical stress was exerted on the sternum at arm flexion and abduction, and the values of the sternal skin strain (SSS) were negative. Besides, the results of SSS did not differ statistically at 90° and 180° arm flexion and comprised about 10.8%, and were statistically lower at 180° abduction than at 90° abduction [8].

The confirmed absence of impact of load increase within certain limits on the level of pain is consistent with the data of Ge W. et al., who found that load increase to lift it overhead resulted in negative dynamics of SSS (from -3.6% to -6.8%) [8].

The obtained results do not correlate with the fact that the use of external sternal fixation reduces pain on coughing [11], confirming the findings of the previous studies on the absence of impact on the level of pain [9, 13]. At the same time, new data were obtained on the absence of impact of a thoracic postoperative bandage on the level of pain when raising the arms forward, sideward, upward both with and without additional loading.

CONCLUSION

A survey of patients confirmed that the use of a postoperative thoracic bandage is characterized by a slight degree of tension, which does not restrict deep breathing and, consequently, cannot limit the increase in chest circumference during separation. The assessment of tension performed by physical therapists was consistent with the patients' responses. The use of a bandage did not reduce the level of pain when moving the upper extremities and coughing. The levels of pain were the highest on coughing.

Contributors:

Vitomskyi V.V. – conceptualization, methodology, formal analysis, investigation, resources, writing – original draft, project administration;

Vitomaska M.V. – visualization, writing – review & editing;

Lazarieva O.B. – data curation, supervision.

Funding. This research received no external funding.

Conflict of interests. The authors declare no conflict of interest.

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Стаття надійшла до редакції
06.08.2021

