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Initial Experience with External Thoracic Stabilization by the »Figure of Eight« Osteosynthesis in Polytraumatized Patients with Flail Chest Injury

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A B S T R A C T

The aim of this study was to describe initial experience with external thoracic stabilization by the »figure of eight« osteosynthesis in polytraumatized patients with flail chest injury. From January 2002, fifteen patients underwent this surgical procedure at the University Hospital of Rijeka. Their mean age was 52 ± 13.69 (range 18–65) and mean ISS was 29.8 (range: 20–41). Twelve patients were weaned from artificial respiration on same day when operated, two on the post-operative day 1, and one on the post-operative day 2. Their stay within the intensive care unit following extubation was within the range of 1–12 days (mean 3.93 ± 2.99). The early external thoracic stabilization by the »figure of eight« osteosynthesis was followed by swift extubation of patient and direct normalization of respiratory parameters. This method contributed significantly to patient's shorter stay within the intensive care unit.

Key words: *thoracic stabilization, polytrauma, »figure of eight«, flail chest, rib fracture, sternal fracture, osteosynthesis*

Introduction

A polytraumatized patient with Injury Severity Score (ISS) >18 and flail chest injury is at risk of developing multiple complications[1]. Where such an injury is accompanied by respiratory distress, i.e. insufficient breathing, patient's severe condition becomes increasingly aggravated, developing dependence on artificial respiration[2]. The thoracic instability leads to respiratory insufficiency caused by obstructed chest wall functions and integrity, accompanied by painful breathing and repercussions on the pulmonary parenchyma and gas exchange. The patient's condition is additionally aggravated by accompanying contusions of the pulmonary parenchyma, atelectasis, difficult tracheo-bronchial toilette, and pneumonia[3]. Such a condition requires uninterrupted ventilatory support and prolonged stay within the intensive care unit (ICU)[4–6]. Extended dependence on artificial ventilation has been proved to cause a series of other respiratory complications, in addition to patient's inability to move.

Polytraumatized patients with flail chest injury, who had been previously treated at the Department of Thoracovascular Surgery of the Rijeka University Hospital, Rijeka, Croatia, by conservative methods, i.e. by internal fixation, used to be unable to move and depended on artificial ventilation for three weeks at the minimum and even more in some cases. Complications developed almost in all of them as a consequence of the extended time of intubations and bed-ridden condition[7,8].

Having considered other authors' stabilization methods[9–15], we started implementing the early external thoracic stabilization by the 'figure of eight' osteosynthesis in January 2002. The principle involves direct approach to fractured ribs, in most cases involving the longer ones (4^{th} to 10^{th} rib), reduction of fractured fragments, and stabilization with Kirschner wire and the 'figure of eight', like tension band osteosynthesis. This paper de-

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scribes our initial experience with the mentioned procedure in polytraumatized patients with flail chest injury, focusing on their earlier weaning from artificial respiration and shorter stay within the ICU, in addition to the normalization of their respiratory parameters and reduction of their exposure to early post-operative complications.

Patients and Methods

We followed up clinical conditions of our patients and established following indications for early external thoracic stabilization by the 'figure of eight' osteosynthesis of ribs in the following cases:

1. patients with deteriorating pulmonary function despite aggressive clearance of bronchial secretions and adequate analgesia, requiring internal pneumatic stabilization and without pulmonary contusion (candidates for early surgical stabilization);
2. intubated patients with previous severe pulmonary contusion and cerebral injuries, in order to reduce the duration of internal pneumatic stabilization when the patient fails to wean from the mechanical ventilation
3. patients with low PaO_2/FiO_2 quotient which demand internal pneumatic stabilization;
4. patients with oxygen blood saturation drop (SO_2%), during the attempt of weaning from mechanical ventilation.

The study included all of the 15 polytraumatized patients with flail chest injury who underwent the early thoracic external stabilization by the 'figure of eight' osteosynthesis. All of the 15 patients were polytraumatized in whom the chest wall instability has been clinically diagnosed upon admittance to ICU, and they were connected to mechanical ventilation immediately. All of them were circulatory and respiratory unstable because of additional injuries (heart contusion, lung contusion, hemorrhagic shock) and we were unable to provide chest wall stabilization until vital functions were under control.

Eleven of patients were male and four female. Their mean age was 52 ± 13.69 (range 18–65). Their injuries had been caused either by a fall or by a traffic accident. Each of them was promptly admitted to the emergency unit, escorted by medical staff. Their ISS range was 20 to 41, mean: 29.8.

Thoracic instability with paradoxical chest wall movement was diagnosed in each of the patients immediately upon their admittance. Five of them have verified multiple serial ribs fractures bilaterally, and 10 of them unilaterally.

Due to accompanied injuries with respiratory and haemodynamic instability, and even disturbed consciousness in some cases, all of the patients were admitted to the ICU and connected to the mechanical ventilation and monitoring of vital functions and respiratory parameters. Immediately upon admittance in ICU, all patient were managed with epidural analgesia

Till patients were on mechanical ventilation, their respiratory parameters were satisfactory. After stabilization of vital functions all of the patients were connected to continuous positive airway pressure (CPAP) ventilation mode and their respiratory parameters were deteriorating during the period from two minutes to two hours. Breathing deterioration was consequence of chest wall instability. Immediately they were brought back to controlled mechanical ventilation and prepared for surgery. When their vital parameters were satisfactory stabilization of ribs fractures was performed within the 3 to 13 days after their admittance into the hospital (7.73 ± 3.57 days). Surgical stabilization of the unstable thorax was done in general endotracheal anesthesia due to the need of lung and pleural cavity exploration, using the double lumen endotracheal tube.

Patient's position and the thoracic incision were done in correlation with the location of the instable segment of the thorax. Antero-lateral instable segments were approached by the antero-lateral incision with the patient positioned on the contra lateral side and the arm abducted at the angle of 90°. In patients with lateral instable segment, we preferred the lateral approach. The patient was, also, on the contra- lateral side, with the arm abducted at the angle of 90°. Incisions shape was adjusted to the location of the fractures. In the same manner we approached the posterior unstable segments by posterior incision. Generally, we tried to avoid massive muscular resection. In case of anterior approach, we bluntly dissected only m.serratus anterior, and in case of lateral and posterior approach m. latissimus dorsi. When needed, we performed minor thoracotomies to explore the pleural cavity and the lungs before beginning the stabilization procedure. In case of pleural effusion or laceration of the lung the thoracic drainage was performed. In most cases, we treated the associated lung injuries conservatively. There was no need for pulmonary resections.

The primary aim of the surgical thoracic stabilization is the elimination of paradoxical thoracic wall movement. Contrary to some other authors we preformed the fixation of the ribs in the centrifugal way, that is, from the center of the thoracotomic wound to its edges. We did not stabilized 1st to 3rd, 11th and 12th rib. Fixation of all long ribs, from 4th to 10th was performed. We approached to each unstable fracture separately with minimal dissection and separation of the ribs periost and intercostal musculature (Figures 1, 2).

After the reposition of fracture fragments, a short Kirschner wire is placed in rib medulla through both of the fragments so it could bridge the fracture. Part of Kirschner wire which is left outside the rib is bent to prevent it from migrating. Figure of eight wire is placed around the rib, without damaging the parietal pleura, in the shape of »eight« and it is tighten over the fracture to maintain compression (Figures 3, 4). We did not use other materials or metal plates (Judet or Sanches)[14]. Closure of the wound was performed in standard manner.

In the same act with thoracic external stabilization, surgical management of additional fractures was per-

Fig. 1. Operation field: reduction, placing of the Kirschner's wire into the rib.

Fig. 2. Operation field: osteosynthesis by means of the »figure of eight«.

formed in seven patients involving osteosynthesis of the clavicle, humerus, femur, pelvis or vertebral stabilization respectively (Table 1).

Postoperatively all of the patients were treated in the ICU on respiratory support for a few hours. When blood gas data were in normal range, patients were extubated. Not a single patient was connected to mechanical ventilation again and their blood gas data were normal afterwards.

Respiratory parameters were monitored before and after the surgery, including the mechanical ventilation dependence time, post-operative time spent within the ICU, and development of early post-operative complications (Table 1). In addition, control chest X-rays and respiratory parameters were followed after 1, 3, and 6 months. Postoperative fluid administration has been individually assessed for each patient based on patient's hemodynamic needs. Central venous pressure, mean arterial pressure, urine output etc. have been monitored hourly or constantly and fluid administration and hemodynamic resuscitation has been based on given values.

Results

After external thoracic stabilization by the 'figure of eight' osteosynthesis twelve patients were weaned from mechanical ventilation on the same day when operated, two of them on the 1st post-operative, and one on the 2nd post-operative (Table 1). After the weaning from mechanical ventilation respiratory parameters were in normal range in all of 15 patients.

Their stay in the ICU following extubation was within the range of 1–12 days (mean 3.93 ± 2.99). Nine patients left the ICU within 1st day, two of them after 1 day, three of them after 2 days, and four of them after 3 days. The other six patients stayed in the ICU more than 3 days for different reasons: febrile conditions, the tracheal cannula removal, brain injury and heart contusion. Patients' data are given in Table 1.

In the post-operative period during hospitalization complications developed in two patients (Table 1) in the form of wound secretion caused by subcutaneous hematoma in the operative wound. Local care was performed

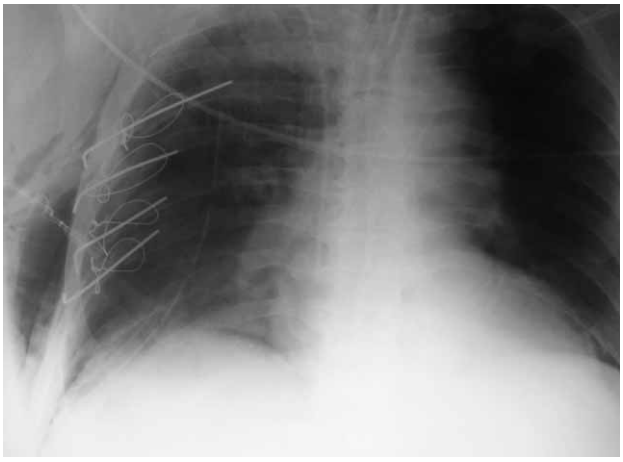

Fig. 3. X-ray: postoperative status, unilateral.

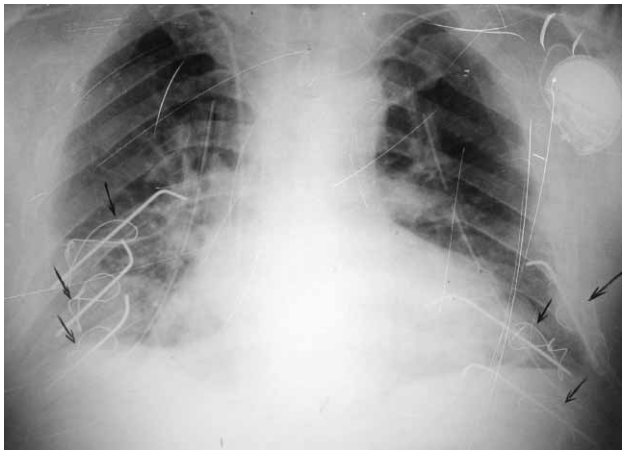

Fig. 4. X-ray: postoperative status, bilateral.

TABLE 1
ADMISSION STATUS, RESPIRATORY PARAMETERS FOLLOW-UP IN ICU, AND POSTOPERATIVE STATUS

PAT	AGE	SEX	MRF	SF	CF	HT	PT	PM	HC	LG	HI	CD	SAI	ARAI	ISS	OP	D	f/min	PaO_2/FiO_2	SO_2%	ETS	SSP	EXT/d	ICU/d	EPOC
1	50	F	b	–	l	–	l	+	+	l	–	–	m	–	25	–	8	38–40	84.37	62–78	9	+	0	1	–
2	55	M	l	–	–	l	l	–	–	l	+	–	m	–	29	–	12	14–20	158.75	82–98	13	–	0	5*	+
3	57	M	b	–	–	b	b	–	–	b	+	–	s	–	24	–	3	34–43	108.75	65–87	4	+	0	2	–
4	49	M	l	–	–	l	l	–	+	b	+	–	m	–	29	–	4	35–37	200	92–98	5	+	0	2	–
5	57	M	b	+	–	b	b	–	+	b	–	–	m	–	20	–	3	30–37	137.5	92–97	4	+	0	12**	–
6	63	M	r	–	–	–	r	–	–	–	+	–	–	+	20	+	11	33–36	111.25	77–88	12	–	0	1	–
7	55	M	b	–	l	r	–	–	–	–	+	–	–	+	36	+	5	30–35	170.62	75–90	6	+	0	4***	+
8	18	F	l	–	–	–	l	–	–	l	–	–	–	+	32	+	10	16–27	197.5	81–98	11	–	0	4***	–
9	25	F	l	–	–	l	–	–	–	l	+	–	m	–	25	–	11	31–37	144.37	86–96	12	–	2	9****	–
10	50	M	l	–	l	–	l	–	–	–	+	+	–	–	32	+	12	27–36	151.25	80–97	13	–	1	5****	–
11	48	M	l	–	–	–	l	–	–	–	+	–	m	+	41	+	5	17–25	354.37	63–77	6	+	0	3	–
12	65	M	l	+	–	b	–	–	–	–	–	–	s	–	41	–	6	15–22	110.62	64–79	7	+	0	3	–
13	61	M	b	–	–	b	–	–	–	–	–	–	m	–	25	–	4	17–27	281.25	95–97	5	+	0	3	–
14	63	M	l	–	–	–	l	–	–	–	–	–	–	+	32	–	2	34–41	71.25	67–88	3	–	0	2	–
15	64	F	r	–	–	–	r	–	–	–	+	–	–	+	36	–	5	37–40	82.5	62–80	6	–	1	3	–

PAT – patient number, MRF – multiple ribs fractures, l – left, r – right, b – billateral, SF – sternal fracture, CF – clavicular fracture, HT – haematothorax, PT – pneumothorax, PM – pneumomediastinum, HC – heart contusion, LC – lung contusion, HI head injuries, CD – consciousness disturbances, SAI – skeletal associated injuries, m – multiple, s – single, ARAI – abdominal and retroperitoneal associated injuries, ISS – Injury Severity Score, OP – operation on admittance day due to haemodynamic instability, D – days spent in ICU, f/min – range of respiratory frequency, PaO_2/FiO_2 – Horowitz quotient on the day of surgery, SO_2% – oxygen blood saturation, ETS – day of External Thoracic Stabilization, SSP – synchrone surgical procedures, EXT/d – postextubation time in days, ICU/d – postoperative time within ICU in days, * up to the removal of a tracheal cannula, ** heart rhythm instability, *** febrility, **** up to the improvement of consciousness disturbances and CT findings, EPOC – early postoperative complications.

on a daily basis and wound healing was achieved within the range of 5–8 days. At follow-up visits after 1, 3 and 6 months chest X-rays and respiratory functions were normal in all patients.

Discussion

Polytrauma represents a very frequent injury in industrially developed regions with intensive traffic conditions. The treatment of polytraumatized patients requires a multidisciplinary approach, and moreover, when their respiratory functions are at risk, the treatment becomes additionally complicated[2]. In cases where their respiratory instability and insufficiency is caused by the loss of thoracic integrity, it is indispensable for patients to be treated within the ICU, where their stay is prolonged owing to their dependence on artificial respiration[6].

According to experience of other medical centers worldwide, we notice that even today thoracic internal fixation i.e. the mechanical ventilation has still been widely used in the treatment of those patients. There was an increased incidence of different complications recorded in those patients, involving both the respiratory and other organ systems.

Having followed up different papers dealing with the treatment of those patients by means of the early open thorax external surgical stabilization[11], we carried out the external stabilization by means of the 'figure of eight' osteosynthesis immediately preceded by the stabilization of patients' vital functions. In selecting this stabilization method like tension band osteosynthesis, we were guided by other authors' experiences[5]. The aim of this method was also to use the minimum quantity of osteosynthetic material.

Evidently, all of the patients observed – irrespective of their other organ systems injuries – had an early weaning from artificial ventilation (0–2 days) and short stay in the ICU (3.93 ± 2.99 days). Their respiratory parameters remained normal after extubation and also in the post-operative course. Respiratory complications were not observed in these patients either in the early post-operative course or during the rehabilitation procedure. Development of wound hematoma in operative wound did not significantly influence the treatment and outcome in 2 patients.

Conclusion

It may be concluded that the early external thoracic stabilization by the means of the »figure of eight« osteosynthesis in polytraumatized patients with flail chest injury contributes to their shorter dependence on artificial respiration and time spent within the ICU and it also significantly contributes to reduced incidence of complications caused by prolonged chest intubation and bed-ridden condition. Post-operative complications are neither frequent nor widespread, allowing the patients' early rehabilitation. Taking into consideration that all of the patients observed had normal respiratory parameters even after 6 months our standpoint is that the early external thoracic stabilization by the means of the 'figure of eight' osteosynthesis is acceptable in the treatment of polytraumatized patients with flail chest injury. Further prospective randomized studies are needed in future to prove that this method is superior to internal stabilization with mechanical ventilation.

REFERENCES

1. BRENNEMAN FD, BOULANGER BR, MCLELLAN BA, REDELMEIER DA, J Trauma, 44 (1998) 580. — 2. KEEL M, TRENTZ O, Injury, 36 (2005) 691. — 3. ANDREWS P, AZOULAY E, ANTONELLI M, BROCHARD L, BRUN-BUISSON C, DE BACKER D, DOBB G, FAGON JY, GERLACH H, GROENEVELD J, MANCEBO J, METNITZ P, NAVA S, PUGIN J, PINSKY M, RADERMACHER P, RICHARD C, TASKER R, Intensive Care Med, 32 (2006) 207. — 4. VILLAR J, KACMAREK RM, PEREZ-MENDEZ L, AGUIRRE-JAIME A, Crit Care Med, 34, (2006) 1311. — 5. ATHANASSIADI K, GERAZOUNIS M, THEAKOS N, Eur J Cardiothorac Surg, 26 (2004) 373. — 6. GUNDUZ M, UNLUGENC H, OZALEVLI M, INANOGLU K, AKMAN H, Emerg Med, 22 (2005) 325. — 7. MORTELLITI MP, MANNING HL, Am Fam Physician, 65 (2002) 1823. — 8. TERRAGNI PP, ROSBOCH GL, LISI A, VIALE AG, RANIERI VM, Eur Respir J Suppl, 42 (2003) 15. — 9. TANAKA H, TAJIMI K, ENDOH Y, KOBAYASHI K, Surg Toda, 30 (2001) 12. — 10. TANAKA H, YUKIOKA T, YAMAGUTI Y, SHIMIZU S, GOTO H, MATSUDA H, SHIMAZAKI S, J Traum, 52 (2002) 727. — 11. BALCI AE, EREN S, CAKIR O, EREN MN, Asian Cardiovasc Thorac Ann, 12 (2004) 11. — 12. BIBAS BJ, BIBAS RA, Eur J Cardiothorac Surg, 29 (2006) 1064. — 13. MAYBERRY JC, TERHES JT, ELLIS TJ, WANEK S, MULLINS RJ, J Trauma, 55 (2003) 835. — 14. SANCHEZ-LLORET J, LETANGE, CALLEJA MA, CATALÁN M, CANALIS E, MESTRES CA, Thorac Catrdiovasc Surg, 30 (1982) 294. — 15. REBER P, RIS HB, INDERBITZI R, STARK B, NACHBUR B, Scand J Thoracic Surg, 27 (1993) 132.

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POČETNO ISKUSTVO SA VANJSKOM STABILIZACIJOM PRSNOG KOŠA METODOM »OSMICE« KOD POLITRAUMATIZIRANIH PACIJENATA S NESTABILNIM THORAXOM »FLAIL CHEST« OZLJEDOM

S A Ž E T A K

Cilj ovog članka je opisati naše rano iskustvo vanjske stabilizacije prsnog koša pomoću metode »osmice« kod politraumatiziranih pacijenata sa »flail chest« ozljedom. Rečeni kirurški postupak učinjen je u KBC Rijeka na 15 pacijenata od siječnja 2002. godine. Prosječna dob pacijenata bila je 52 ± 13,69 (raspon 18–65) te prosječni ISS 29,8 (raspon 20 do 41). Dvanaest pacijenata odvijeno je od mehaničke ventilacije na dan operacije, 2 pacijenta 1. poslijeopracijski dan, a jedan pacijent 2. poslijeoperacijski dan. Liječenje pacijenata u JIL-u nakon ekstubacije trajalo je 1–12 dana (prosječno 3,93 ± 2,99). Vanjska stabilizacija prsnog koša metodom osmice rezultirala je brzom odvajanju pacijenata od mehaničke ventilacije te je pridonijela značajno kraćem boravku u jedinici intenzivnog liječenja.