Long-term disability after blunt chest trauma: Don't miss chronic neuropathic pain!

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Summary conflict of interest statements: no conflicts exist for the current study. Only departmental funds were used for this study. No external funds were obtained.

KEY WORDS: Chest trauma; Chronic pain; Neuropathic pain; Respiratory disability; Intensive Care

ABSTRACT

INTRODUCTION: The main objective of this prospective study was to assess the incidence of chronic pain and long-term respiratory disability in a single-center cohort of severe blunt chest trauma patients.

METHODS: Over a 10-month period, all consecutive blunt chest trauma patients admitted in Intensive Care Unit (ICU) were screened to participate in a 3-month and 12-month follow-up. The following variables were prospectively assessed: persistence of chronic chest pain requiring regular used of analgesics, neuropathic pain, respiratory disability, physical and mental health status. Univariate and multivariable analysis were conducted to assess variables associated with chronic chest pain, neuropathic chest pain and respiratory disability.

RESULTS: During the study period, 65 patients were included in the study. Chronic chest pain and respiratory disability were reported in 62% and 57% of patients respectively at 3 months postinjury. Neuropathic pain was reported in 22% of patients, associated with higher impairment of quality of life. A thoracic trauma severity score ≥ 12 and a pain score ≥ 4 at SICU discharge were the only variables significantly associated with the occurrence of neuropathic pain at 3 months (OR = 7 [2 - 32], $p = 0.01$ and OR = 16 [4 - 70], $p < 0.0001$).

CONCLUSION: According to the current study, chronic pain and long-term respiratory disability are very common after severe blunt chest trauma patients. Special attention should be paid to neuropathic pain, frequently under-diagnosed and responsible for significant impairment of quality of life.

KEY WORDS: Chest trauma; Chronic pain; Neuropathic pain; Respiratory disability; Intensive Care

INTRODUCTION

Blunt chest trauma remains an issue in the acute care settings, potentially leading to secondary respiratory complications depending on the severity of injuries and the patient's conditions.[1] In this context, implementation of clinical pathways and multidisciplinary interventions may reduce the rate of secondary respiratory complications and improve patient outcomes.[2 – 6] On the other hand, little is known about the long-term outcome of such multimodal strategies.[7 – 9] Historical cohort studies have reported up to 50% of chronic pain and long term disability after blunt chest trauma, associated with a significant impairment of quality of life. [10, 11]

Prevention of chronic pain is of paramount importance as it remains a leading cause of work loss, high utilization of health-care resources, major depression and analgesic misuse. [12] Although the intensity of acute pain has been associated with chronic pain, very few cohort studies described the initial analgesia and ventilation strategies during the acute care settings. [11, 12] We thus hypothesized that a better control of analgesia in the acute care settings could improve the long-term disability. Furthermore, the characteristics of chronic pain remain poorly documented, whereas the neuropathic component could benefit from a specific treatment. [13, 14]

The main objective of this prospective study was thus to assess the incidence of chronic pain and long-term respiratory disability in a single-center cohort of severe blunt chest trauma patients. The secondary objective was to determine predictive factors associated with chronic pain or long-term respiratory disability.

METHODS

1. Population and settings

Over a 10-month period (June 2016 to March 2017), all consecutive patients admitted in our Surgical Intensive Care Unit (SICU) for a blunt chest trauma with more than 3 rib fractures were considered to participate in a 3-month and 12-month follow-up. During this period, every patient was managed according to a bundle of care developed from the up-to-date French guidelines (**Table 1**).

For all eligible patients, an intensivist-led follow-up visit was scheduled 3 months after ICU admission (September 2016 to July 2017). Non-inclusion criteria were patients < 18 or ≥ 80 years old, institutionalized, with cognitive disorders or refusing to participate. Secondary exclusion criteria were intercurrent death or loss of follow-up. All patients included during the 3-month visit were contacted by phone for a 12-month follow-up (June 2017 to March 2018).

The observational character of this prospective, single-center study was confirmed by the Institutional Review Board (CHU Bordeaux, France; protocol CE-GP-2018-03) which waived the need for written consent. Patients or next of kin were orally informed of the goal and design of the study.

2. Data collection and outcomes

During the acute phase settings, the following variables were retrospectively collected in the ICU medical record: demographic data, preinjury social and medical status, thoracic and associated injuries, Injury Severity Score (ISS), Simplified Acute Physiology Score II (SAPS II) and Thoracic Trauma Severity (TTS) score, [15] type of pain control (thoracic paravertebral infusion, epidural analgesia or intravenous pain control), chest tube requirement, indication for surgical rib fixation, use of invasive or non-invasive ventilation, complications during the SICU stay (pulmonary infection and acute respiratory distress syndrome [ARDS] following Berlin definition, [16] SICU and hospital length of stay (LOS). Measurements of forced vital capacity (FVC) and mean visual analogue scale (VAS) pain scores were collected at SICU admission and SICU discharge.

During the 3-month follow-up visit, the following variables were prospectively assessed: resumption of professional activity in previously working patients, persistence of chronic chest pain, disability and pain relief assessed by the Brief Pain Inventory (BPI)[17], physical and mental health status assessed by the SF-36 norm-based summary scores. [18] Chronic pain was defined by a persistent chest pain requiring regular used of analgesics. Analgesic consumption and characteristics of pain were noted. Costal pain was defined as a localized pain in the fractured-ribs area and increased by palpation. Pleural pain was defined by a basithoracic, inflammatory pain, increased by deep inspiration and relieved by NSAIDs, with the presence of residual effusion on the control chest radiographs. Neuropathic pain was defined by a DN4 score ≥ 4/10. [19] Respiratory disability was assessed by the NYHA scale, measurements of SpO_2 and FVC at rest. FVC and forced expiratory volume per second (FEV_1) were measured using a hand-held spirometer (Spirobank^{TM}, MIR Laboratory, Rome, Italy).[20] Each respiratory maneuver was repeated three times and only the best performance was recorded. Respiratory disability was defined by one or more of the following: NYHA

score ≥ 2, SpO_2 ≤ 92% or FVC ≤ 80% at rest. Finally, the persistence of a pleural effusion was recorded on the chest X-rays performed before the 3-month follow-up visit.

During the 12-month follow-up phone call, the following variables were prospectively assessed: resumption of professional activity in previously working patients, persistence of chronic chest pain (BPI score), analgesic consumption, characteristics of pain (DN4 score) and respiratory disability (NYHA scale).

3. Statistical analysis

Results are expressed as mean (standard deviation) or median (25% to 75% interquartile range) for continuous variables and as numbers (percentages) for categorical variables. The data distribution was analyzed by a Kolmogorov-Smirnov test. Comparisons between continuous variables were performed using the Student *t* test or the Mann–Whitney test and categorical variables were compared using the chi-square test.

Univariate analysis was conducted to assess variables associated with chronic chest pain, neuropathic chest pain and respiratory disability during the 3-month follow-up. The accuracy of continuous variable to predict chronic chest pain, neuropathic chest pain and respiratory disability was assessed using a receiving operator curve (ROC) analysis. The best threshold values were chosen to maximize Youden index. These thresholds were subsequently used for logistic regression and multivariable analysis. Variables associated with a $P < 0.1$ in univariate analysis were assessed in multivariable analysis using a logistic regression model.

A *p* value < 0.05 was considered statistically significant. Statistical analyses were performed using XLSTAT 2015 for Windows (Addinsoft Paris, France).

RESULTS

1. Population

During the study period, 96 consecutive patients were admitted for a severe blunt chest trauma. Thirty-one patients were not included for the 3-month follow-up (24 refusing to participate, 4 ≥ 80 years old and 3 deaths). Finally, 65 patients were included in the study. Their main characteristics are shown in **Table 2**. Among these patients, only one died before the 12-month follow-up phone call. Among the 43 preinjury working patients, only 4 (9%) had returned to work at 3 months and 26 (60%) at 12-months.

2. Chronic pain

The incidence of chronic chest pain was reported in 40 patients (62%) during the 3-month follow-up visit, with 15 (23%) presenting a mean VAS pain scores at rest ≥ 4. Seventeen patients (29%) were still undergoing opioid therapy for pain-relief. Chronic chest pain was mainly attributed to costal pain in 24/65 patients (37%), pleural pain in 3/65 (3%) patients and neuropathic pain in 14/65 (22%) patients. One patient had multiple pain diagnosed (costal and pleural). Among the 40 patients with chronic chest pain, the mean VAS pain scores at rest was significantly higher in patients showing neuropathic pain [4.1 (1.8) vs. 3 (1), *p = 0.03*]. However, no patient with neuropathic pain was undergoing specific treatment. Neuropathic pain was associated with higher impairment of quality of life (**Figure 1**). During the 12-month follow-up phone call, a persistent chest pain requiring regular used of analgesics was noticed in 19/64 patients (30%), with 9/64 (14%) undergoing opioid therapy for pain-relief. Neuropathic pain was still predominant in 10/64 patients (16%), only 5 of them receiving a specific treatment.

None of the studied variables (demographic data, injury status or ICU management) were statistically associated with the occurrence of chronic chest pain. Only two factors were statistically associated with neuropathic pain at 3 months: the TTS score (14 [13 – 18] vs. 11 [9 – 14], *p = 0.006*) and the VAS pain scores at SICU discharge (3 [1 – 4] vs. 2 [0 – 2], *p = 0.002*). The best threshold values for TTS score and VAS pain score to predict neuropathic pain at 3 months were respectively 12 (sensitivity 75% [46 – 92]; specificity 68% [54 – 80]) and 4 (sensitivity 58% [32 – 81]; specificity 94% [82 – 98]). The ROC curves are displayed in **Figure 2**. In multivariable analysis, a TTS score ≥ 12 and a VAS pain score ≥ 4 at SICU discharge remained the only variables significantly associated with the occurrence of neuropathic pain at 3 months (OR = 7 [2 - 32], *p = 0.01* and OR = 16 [4 - 70], *p < 0.0001*).

3. Respiratory disability

Long-term respiratory disability was documented in 37 patients (57%) during the 3-month follow-up visit, 36 (55%) reporting a dyspnea score ≥ 2, 8 (12%) reporting a FVC < 80% and one (2%) reporting a SpO_2 ≤ 92% at rest. Twenty five patients reported a significant alteration in respiratory function compared to pre-injury period. Six patients (9%) kept a moderate (N = 5) or severe (N = 1) pleural effusion of chest X- rays. Mean FVC and FEV_1 were 89 (22) % and 89 (22) % respectively. During the 12-month follow-up phone call, 7/25 patients were still suffering from respiratory disability (NYHA ≥ 2).

At 3 months, there was a significant association between the persistence of chronic pain and long-term respiratory disability [13/28 (46%) vs. 27/37 (73%), *p = 0.03*]. However, there was no statistical difference in FEV_1 and FVC between patients without chronic pain, with non-neuropathic chronic pain and neuropathic chronic pain. Patients with ARDS occurring during the acute care settings showed significantly lower FEV_1 and FVC [74 (13) vs. 91 (23) %; *p = 0.006 and* 88 (29) vs. 100 (21) %; *p = 0.01,* respectively] at 3 months postinjury. Patients with persistent pleural effusion showed significantly lower FEV_1 and FVC [67 (14) vs. 91(22) %; *p = 0.006* and 72 (13) vs. 101 (21) %; *p = 0.01,* respectively] at 3 months postinjury.

Among the studied variables, only the TTS score (12 [11 – 16] vs 10 [8 – 14], *p = 0.02*) was statistically higher in patients with long-term respiratory disability. After logistic regression, a TTS score > 12 was associated with the occurrence of long-term respiratory disability with an OR = 5 [2 - 14], *p = 0.002*. A TTS > 12 was not statistically associated with lower FEV1 and FVC values at 3 months postinjury.

DISCUSSION

The main objective of this study was to assess the incidence of chronic pain in a single-center cohort of severe blunt chest trauma patients managed by a multidisciplinary bundle of care.[5] Despite a strict control of analgesia in the acute care settings, the incidence of chronic chest pain remained high, respectively reported in 62% at 3 months and 30% at 12 months postinjury. The long-term disabilities were responsible for alterations of quality of life and loss of productivity, 40% of preinjury active patients not being returned to work during a 12-month follow-up.

In comparison with literature, the rate of chronic chest pain requiring regular use of analgesics is higher than previously reported, ranging from 22 to 59% according to the studies. [11, 21, 22] Several factors could explain those discrepancies. First, our study focused on high-risk blunt chest trauma patients requiring ICU admission, loco-regional analgesia, chest tube insertion and respiratory support. Most of the previously published studies focused on patients admitted in emergency settings, showing lower severity scores and requiring lower levels of care. [11, 21, 22] Moreover, none of these studies reported the characteristics of chronic pain. To our knowledge, the present study is the first to report the incidence of neuropathic chest pain in one third of patients at 3 months postinjury. The neuropathic component was underdiagnosed, no patient undergoing specific treatment before the 3-month follow-up. Neuropathic pain was associated with higher impairment of quality of life.

Despite the high incidence of blunt chest trauma worldwide, risk factors of post-traumatic chronic pain are poorly described. In our study, only the TTS score and the VAS pain scores at SICU discharge were statistically associated with the occurrence of neuropathic pain at 3 months postinjury. Although the current study found no association between the type of pain control and the occurrence of chronic chest pain, the use of locoregional analgesia has been associated with a

reduction of chronic pain in the perioperative settings.[23, 24] It is thus possible that a strict control of analgesia in the acute settings could impact on long-term pain and functional outcome, especially in high risk trauma patients. However, no study focusing on analgesia in blunt chest trauma patients have followed the patients to find any difference in long-term pain syndrome.[25-27] A specific management of neuropathic pain may improve the long-term outcome.

Finally, more than a half of patients were suffering from respiratory disability during the 3-month follow-up. On the other hand, only few patients showed objective alterations of pulmonary function tests, without statistical association with chronic chest pain. These results could mean that the subjective experience of dyspnea is actually more related to chronic chest pain than to an objective alteration of pulmonary function. Patients with ARDS occurring during the acute care settings showed significantly lower FEV_1 and FVC at 3 months postinjury, in accordance with other studies in non-trauma patients.[28] Moreover, special attention should be paid in patients with persistent pleural effusion. Respiratory muscle training by physiotherapist may have an interest to reduce the subjective feeling of respiratory disability one year postinjury.

This study was impaired by several limitations. First, the results are extracted from a single-center study conducted in a specific population of Surgical and Trauma ICU patients and thus are not generalizable to every blunt chest trauma patients. One of the main limitations is the great heterogeneity between patients, including multiple trauma patients and isolated chest trauma. Moreover, our study does not allow comparison between the rate of chronic pain before and after implementation of clinical pathway and multidisciplinary bundle of care. Finally, the one-year follow up was only made by phone call, precluding any physical examination or respiratory function tests.

CONCLUSION

According to the current study, chronic pain and long-term respiratory disability are very common after severe blunt chest trauma patients. Only a specific follow-up can detect long-term complications and provide a specialized management in order to improve the long-term outcome and quality of life.

AUTHOR'S CONTRIBUTION

CC helped to conceive the study and design the trial, supervised the conduct of the trial and data collection, and helped to analyse the data and to draft the manuscript. CC and YG were in charge of the follow-up visit at 3 months. YG made the 12-month phone call. LP, LDM and VC helped to conceive the study and design the trial. LP, LDM and VC helped to undertake recruitment of participating patients. FS and MB helped to provide statistical advice on study design, to analyse the data, and to draft the manuscript. CC and MB have personally reviewed the data and confirmed that the methods are clearly described and that they are a fair way to report the results. All authors read and approved the final manuscript.

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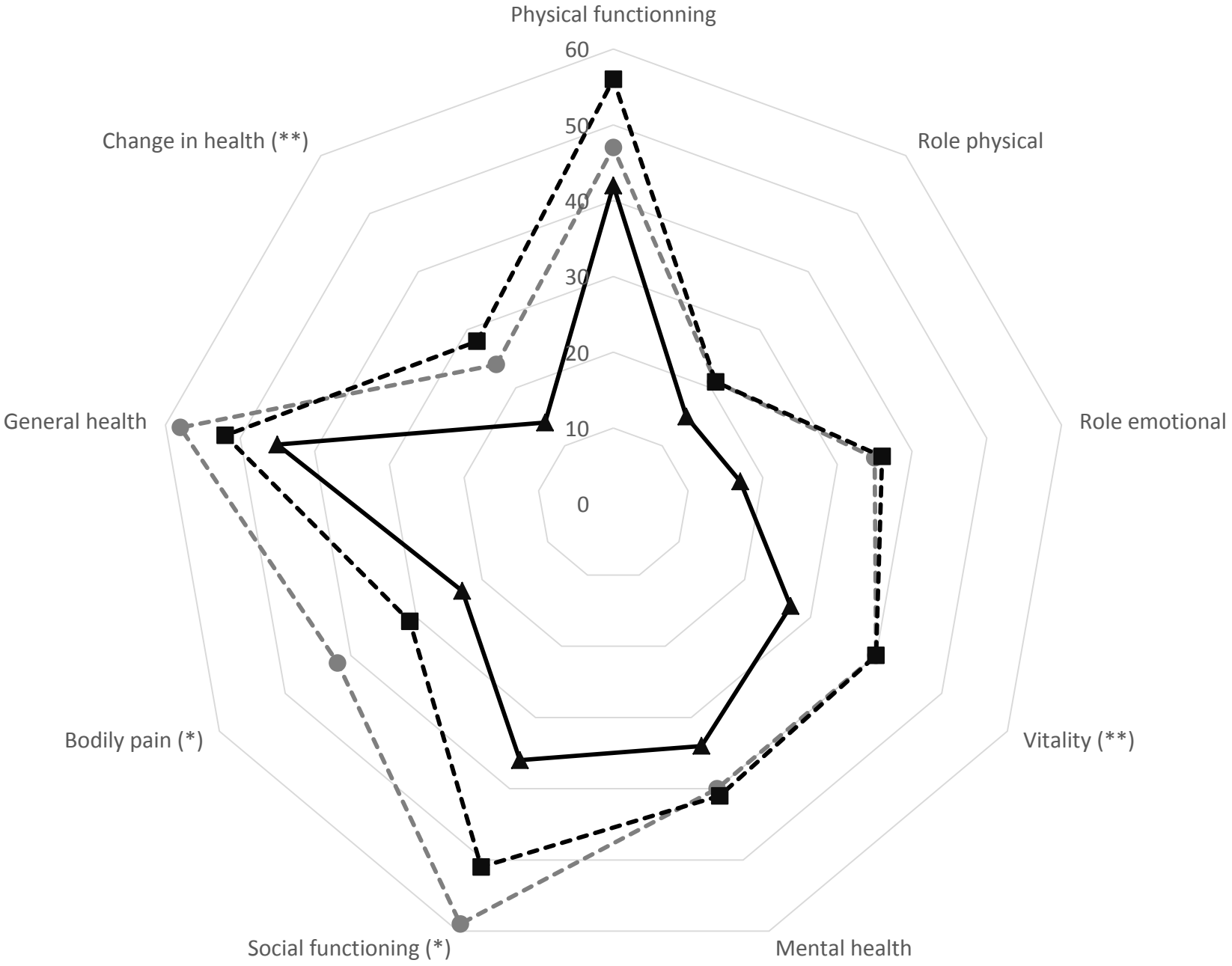
A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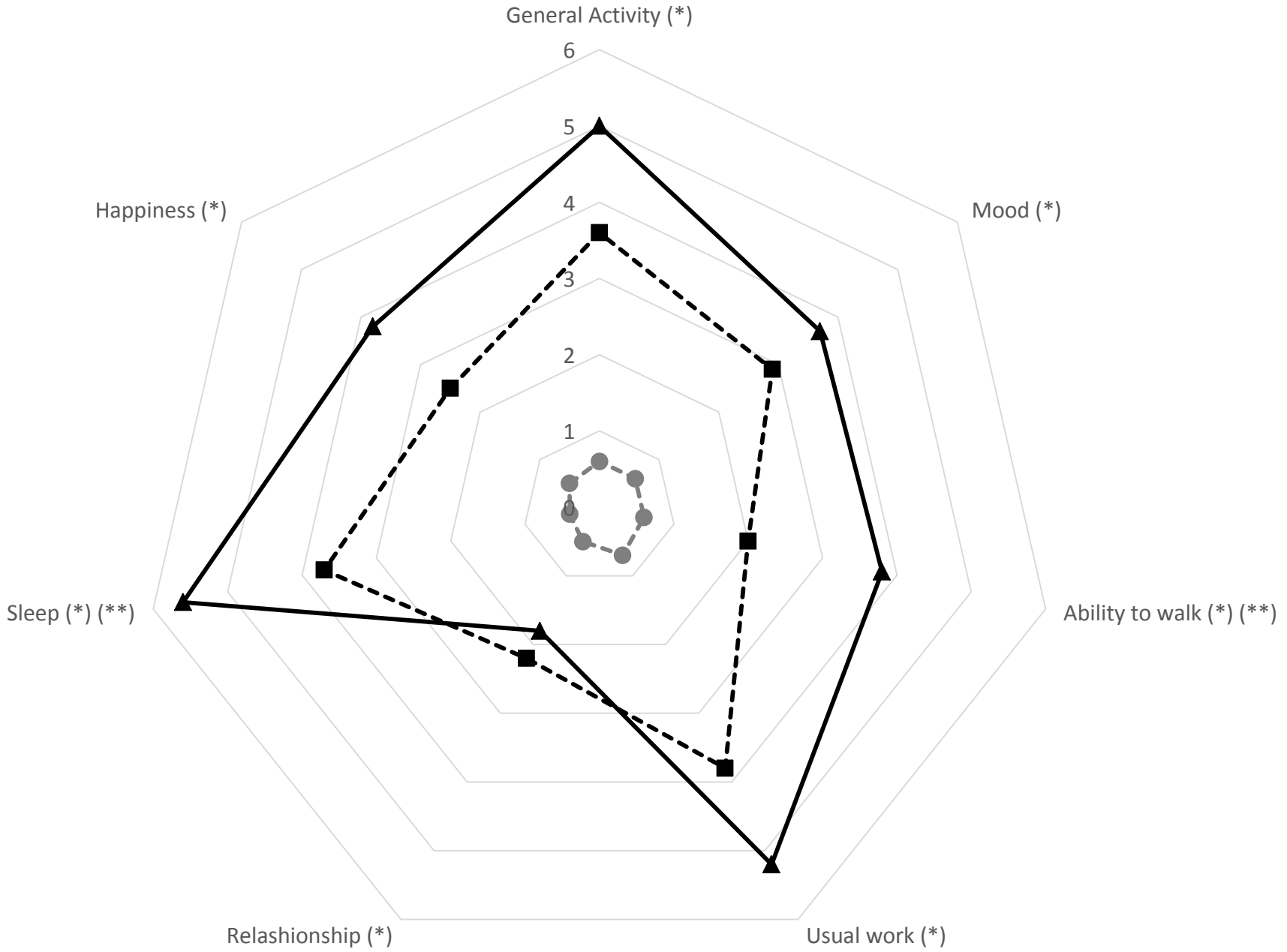
Change in health (**)

B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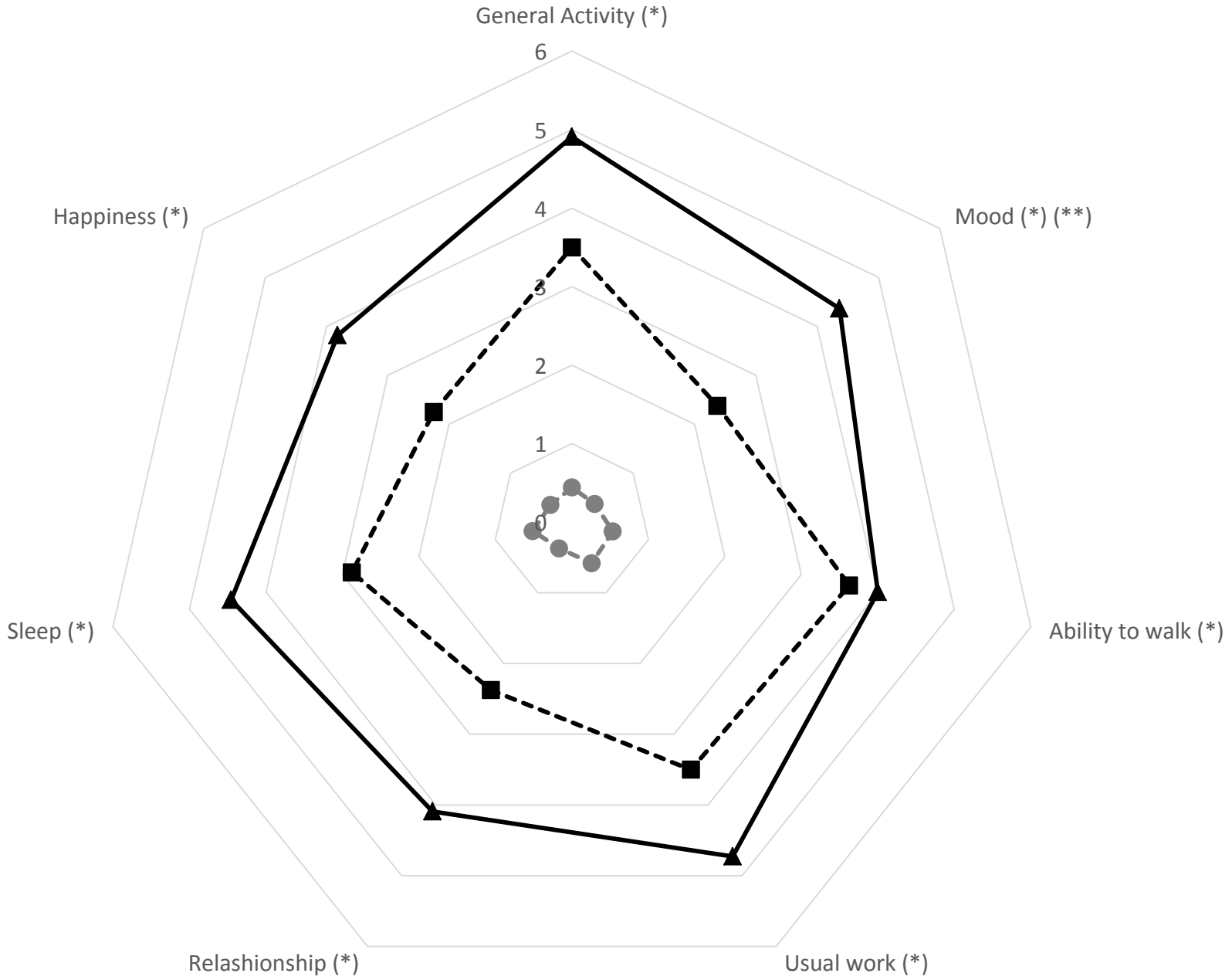
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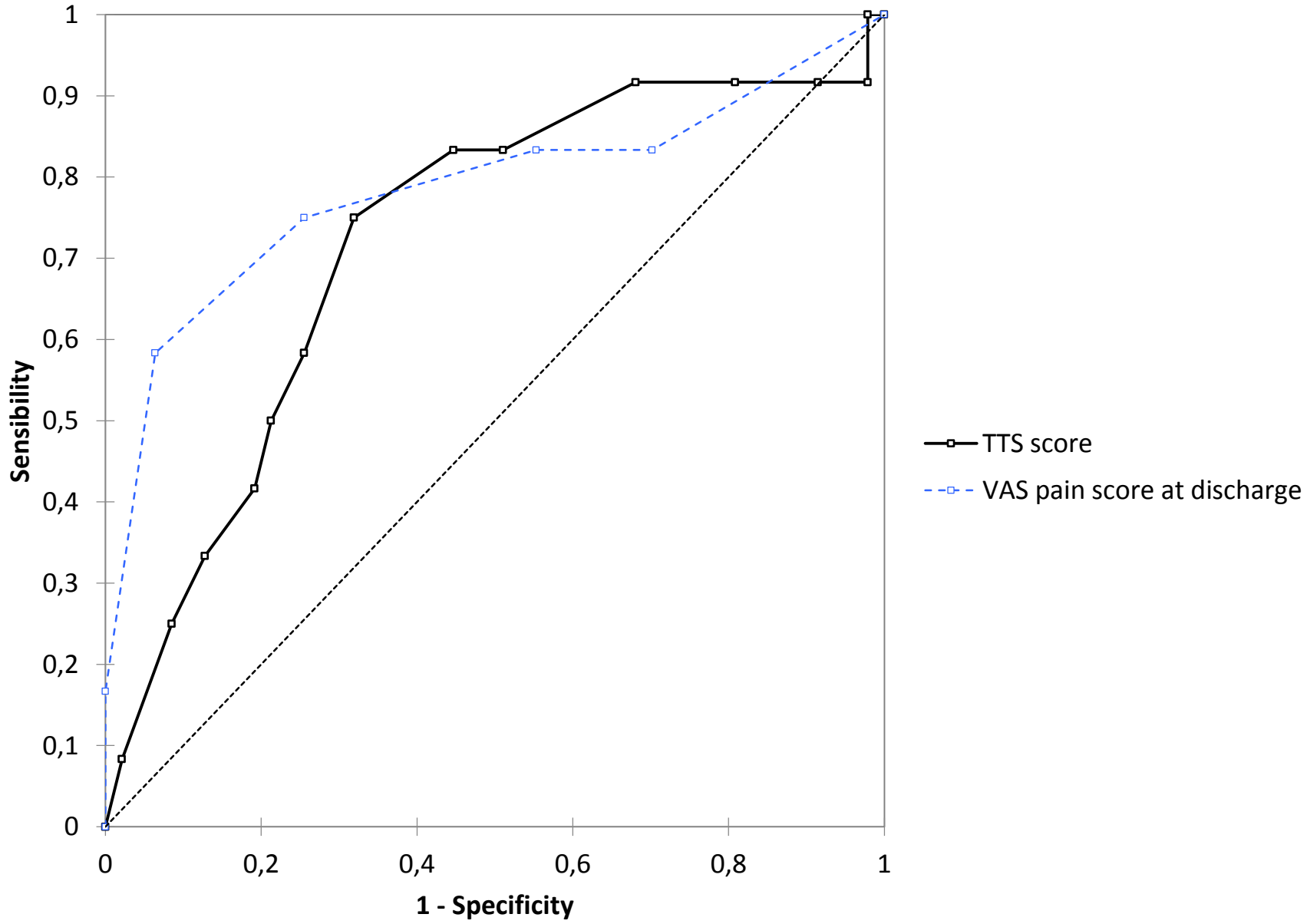
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1 - Specificity
TTS score
VAS pain score at discharge

Table 1. Bundle of care for chest trauma patients in the Surgical Intensive Care Unit

1. Repeated assessment of pain score and functional respiratory status - Repeated assessment of visual analog pain scale (VAS) at rest, coughing and deep breathing - Repeated assessment of forced vital capacity (FVC) by portable spirometer [19]
2. Intravenous analgesia - Morphine and/or ketamine titration until resting VAS < 3. - Multimodal analgesia including non-steroid anti-inflammatory drugs (NSAIDs), nefopam and ketamine unless contra-indicated. - Addition of morphine intravenous patient-controlled analgesia if persistence of VAS > 3.
3. Locoregional analgesia - If persistence of a VAS > 3 and / or FVC < 50% despite optimized intravenous analgesia, preferably in high-risk patients. - Indication and technique (epidural and paravertebral catheters) left to the discretion of the attending physician unless specific contra-indication.
4. Chest tube insertion - In case of traumatic pleural effusion responsible for hemodynamic and/or respiratory failure or hemothorax estimated > 500ml. - Indication and technique left to the discretion of the attending physician. Pigtail catheters preferred in isolated pneumothorax with low risk of secondary hemothorax.
5. Respiratory support - Non-invasive ventilation (NIV) indicated if persistent hypoxemia (PaO_2/FiO_2 ratio ≤ 200 mmHg) after CT-scan and chest tube insertion when indicated. Optimal dosing ≥ 6h/day. Strict compliance with contraindications and monitoring procedures. - High-flow nasal cannula oxygen therapy in association with NIV or if NIV contra-indicated.
6. Surgical advice - Discuss indication of osteosynthesis for flail chest and/or complex costal fractures (multiple rib fractures with shift > 2cm)

Table 2. Characteristics of the population

	Overall population N = 65
Demographic data	
- Age	54 [44 – 63]
- Sex, male / female	56 (86) / 9 (14)
- Professional activity	43 (66)
- Cardiorespiratory comorbidities	21 (32)
Chest injuries	
- Number of rib fractures	6 [5 – 10]
- Flail segment	26 (40)
- Pulmonary contusion	44 (68)
- Pneumothorax	41 (78)
- Hemothorax	41 (63)
Co-existing injuries	
- None (isolated chest trauma)	10 (15)
- Multiple trauma	55 (85)
o *Limb fracture*	42 (65)
o *Spine fracture*	27 (42)
o *Abdominal trauma*	22 (34)
o *Craniofacial trauma*	21 (32)
o *Pelvic fracture*	18 (28)
Severity scores at SICU admission	
- SAPS II	26 [20 – 34]
- ISS	25 [16 – 34]
- Chest AIS	4 [3 – 4]
- TTS score	12 [9 – 15]
- VAS pain score	4 [3 – 5]
- FVC	40 [34 – 52]
ICU management	
- Locoregional analgesia	54 (83)
o *Epidural Analgesia*	*33 (51)*
o *Thoracic Paravertebral Infusion*	*21 (32)*
- Intravenous analgesia	
o *NSAIDs*	53 (82)
o *Ketamine*	39 (60)
o *Morphine patient-controlled analgesia*	35 (54)
- Chest-tube requirement	46 (71)
- Respiratory support	
o *Noninvasive ventilation only*	*21 (32)*
o *Mechanical ventilation*	*34 (52)*
- Surgical fixation of rib fracture	9 (14)
- ARDS	9 (14)
- Pulmonary infection	16 (25)
Length of stay	
- SICU (days)	9 [6 – 14]
o VAS pain score at SICU discharge	2 [0 – 3]
o FVC at SICU discharge	67 [60 – 76]
- Hospital (days)	16 [9 – 29]

Results expressed as median [25% to 75% interquartile range] or number (percentage). AIS = Abbreviated Injury Score; ARDS: Acute Respiratory Distress Syndrome [16]; ISS = Injury Severity Score; FVC = Forced Vital Capacity; NSAIDs = Non Steroid Anti Inflammatory Drugs; SAPS = Simplified Acute Physiology Score; SICU = surgical Intensive Care Unit; TTSS = Thoracic Trauma Severity Score; VAS = Visual Analogue Scale.