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Isolated thoracic and lumbar transverse process fractures: Do they need spine surgeon evaluation? a high volume level I trauma center experience with cost analysis

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ABSTRACT

Background: Transverse process fractures (TPF) of the thoracic and lumbar spine have become increasingly identified due to CT imaging. Spine service consultation is common for further evaluation and management. There are several studies that demonstrate no difference in clinical outcome with or without spine service intervention. However, no study to our knowledge provides an additional cost analysis. We hypothesize that isolated thoracolumbar TPF are stable injuries. Furthermore, spine service consultation and evaluation results in increased health care costs.

Methods: Patients were identified using trauma registry data at Saint Louis University (SLU) from January 2012 to August 2018. Chart and imaging review was performed to determine if additional spine fractures were identified by the spine team which were not included in the initial radiology report. TPF associated with other spinal injuries were defined as one or more thoracic and/or lumbar TPF in addition to any other acute fracture or dislocation in the cervical, thoracic, or lumbar spine. A separate cost analysis with institution-specific charges was also performed.

Results: Six hundred eighty-two patients with TPF from January 2012 to August 2018 were identified. Two hundred twenty-eight patients met the criteria to be included in this study. Additional spinal pathology that was not included in the initial radiology report was identified in 5 (2.19%) patients, none of which required surgical intervention. Cost analysis demonstrated additional costs associated with spine service intervention totaled \$1,725,360.28. Average cost per patient in our cohort summed to \$2,529.85

Conclusions: These data support that isolated TPF of the thoracic and lumbar spine are stable injuries that likely do not require spine service intervention and in fact may represent unnecessary financial burden. Foregoing unnecessary consultation can alleviate time constraints within spine service practices and reduce health care costs by eliminating costly extraneous interventions from the patient's care.

Background

Prior to the implementation of whole-body computed tomography (CT) scanning of trauma patients, the regular diagnosis of Transverse Process Fractures (TPF) with XR imaging was rare. The increased sensitivity and resolution of total body CT scanning has resulted in far more of these fractures being identified [1,2]. The significance of these fractures has yet to be fully elucidated. Several studies show that a significant association exists between the radiologic diagnosis of TPF and

severe abdominal, pelvic or additional spinal injuries, as these fractures are associated with high energy traumatic mechanisms [3–9].

The transverse process is a small body projection off the right and left side of each vertebra. These function as the site of attachment for paraspinal muscles and ligaments of the spine as well as the point of articulation of the ribs (in the thoracic spine). A high energy injury mechanism can cause forceful contraction of these muscles resulting in an avulsion fracture of the transverse process. These injuries in isolation do not result in mechanical instability as the support load and axial

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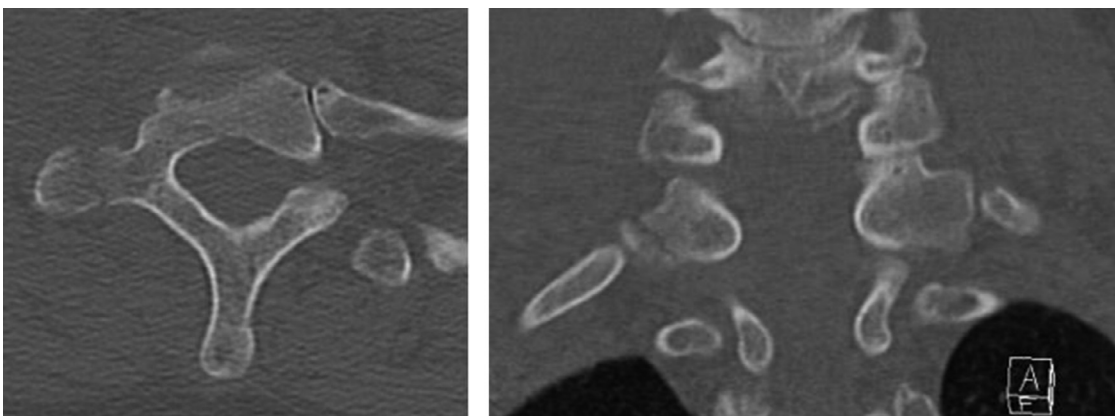


Fig. 1. (A): select axial CT cut of an isolated thoracic transverse process fracture (B): select coronal CT cut of an isolated thoracic transverse process fracture.

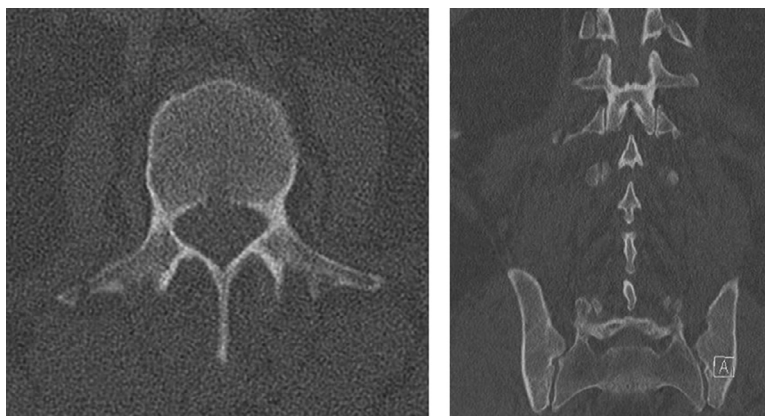


Fig. 2. (A): select axial CT cut of an isolated lumbar transverse process fracture (B): select coronal CT cut of an isolated lumbar transverse process fracture.

stability carried by these attachments is shared by adjacent paraspinal muscles and ligaments with insertion and attachment locations in alternative aspects of the anterior, middle, and posterior columns. This design allows the axial load to be assumed by the vertebral components of the anterior or middle columns, whereas the remaining components of the posterior column may maintain transverse and longitudinal stability even if the transverse process is fractured. Furthermore, these structures are not located in intimate proximity to the spinal canal or nerve roots, and fractured bony fragments do not acquire a position that may result in compromise to the superior or inferior nerve root. TPFs in isolation do not disrupt the mechanical load support functions of the spine, or its relationship to the neurologic elements [5]. They are thought to represent a relatively minor injury compared to other vertebral fractures, and treatment measures include pain management and possible orthotics for comfort, with unrestricted mobilization as tolerated [10].

Several studies have questioned the need for orthopedic spine or neurosurgical consultation after these injuries are identified by the primary team [10–12]. Spine service (neurosurgery or orthopedic) consultation is currently requested for all patients with these fractures within our institution. Referral, evaluation, and interventions taken by the spine team add to the costs of care with questionable benefit. Spine specialty intervention may result in the identification of other spine pathology that could include mechanically unstable fractures or ligamentous injuries or those resulting in neurologic injury [13]. If significant vertebral injuries were identified as a result of spine consultation, this would support the current institutional protocol of automatic consultation as it certainly adds to the quality of patient care. If spine service consultation is not needed, however, deferring these consultations would reduce health care costs by eliminating extraneous care.

This study is a retrospective review using institutional trauma registry data evaluating the hypothesis that isolated transverse process fractures of the thoracic and lumbar vertebrae (Figs. 1 and 2, respectively) are structurally and neurologically stable injuries. The costs of spine service intervention including that of inpatient consultation, additional diagnostic testing ordered, orthoses, and clinic follow-up were determined. The role of operative management or spinal orthotic management to address instability or neurologic injury is expected to be none. The goal of this study is to specifically evaluate the interventions taken by the spine team after consultation for isolated TPF. If confirmed, these hypotheses will provide evidence to allow institutions to develop protocols to reduce the costs of care related to these injuries.

Methods

Patients for this retrospective, institutional review board-approved study were identified using trauma registry data at Saint Louis University (SLU) from January 2012 to August 2018. SLU is an inner-city tertiary care center and trauma hospital with a large catchment area and regional urban, suburban and rural referral base. The trauma registry consists of adult (>18 years of age) trauma patients who presented to SLU as a level 1, 2, or 3 trauma category. Common mechanisms of injury include motor vehicle accident, fall, and assault. The registry was queried for CPT code 22305 (closed treatment of vertebral process fracture) associated with TPFs. Isolated TPF of the thoracic and lumbar spine were categorized by the presence of one or more TPF identified on CT scan. TPF associated with other spinal injuries were characterized by the presence of one or more thoracic and/or lumbar TPF in addition to any other acute fracture or dislocation in the cervical, thoracic, or lumbar spine. Patient charts were further analyzed to determine if addi-

Table 1
Inclusion and exclusion criteria.

Inclusion	Exclusion
Age >18	Age <18
Isolated thoracolumbar TP fractures identified by Radiology without additional spine pathology	Patient's with additional spine pathology identified by Radiology
	Cervical TP fractures
	Polytrauma patients that required bedrest or who could not participate in formal neurologic exam

tional spine fractures, not included in the initial radiology report, were identified by the spine team after image review.

Patients were evaluated for age, gender, fracture location, additional spine pathology identified as a result of the spine consult, neurologic status, initial mobilization restrictions including strict spine or bedrest precautions, additional diagnostic testing, type and cost of orthoses ordered (if applicable), and patients who were seen in outpatient follow up.

Patients with isolated TPF of the cervical spine were excluded in this study due to their known association with brachial plexopathy and vertebral artery dissection or occlusion [14–16]. It was felt by the authors that these fractures be approached differently than those in the thoracolumbar region as these injuries often require additional workup including vertebral angiography [17,18]. Additional spinal fractures other than thoracic or lumbar TPFs that were correctly identified by initial radiology read were excluded after review of imaging and confirmation of diagnostic accuracy. Patients with concomitant injuries that necessitated bedrest status or prevented full neurologic examination at the time of the consult were also excluded. This includes patients with traumatic brain injuries or those with pelvic or lower extremity trauma requiring skeletal traction (Table 1).

Fracture location was recorded according to vertebral level and laterality. Mechanical stability was assessed based on the diagnostic images, including standing/upright spine radiographs when available. Radiographic analysis involved assessment of the facet joints, anterior, middle, and posterior columns, overall alignment, and vertebral listhesis. Mechanically stable fractures were defined as any fracture that was not reported to exhibit facet widening or subluxation, widening of the spinous processes, or focal listhesis at the level of the transverse process fracture. Neurologic injuries were recorded as the presence of newly identified deficits with a possible neurologic origin, including motor, sensory, or cognitive deficits. Those patients with deficits secondary to extraspinal injuries were excluded.

Spine team interventions were recorded as identification of additional vertebral pathology that was not included on the initial radiology read of the spine imaging, activity restriction including bedrest or strict spine precautions, additional diagnostic imaging ordered at the request of the spine team, type and cost of orthoses prescribed, and whether or not the patient was seen in clinic for routine fracture follow-up. The institutional costs of these interventions were obtained and applied to each patient's care in order to assess the approximate cost of interventions taken by the spine or neurosurgical team (Table 2). Our institutional protocol in the trauma setting for traumas meeting Level 1 and Level 2 criteria, includes CT chest/abdomen/pelvis and full spine CT imaging. The cost of these studies was not included in our cost analysis as they are not considered as a specific spine team intervention. Additional imaging specifically requested by the Spine service is included in our cost analysis. Pain scores and medications were not recorded in this study, as pain following a fracture is expected and analgesia could not specifically be attributed to spine team intervention.

Table 2
CPT code descriptions and associated costs.

CPT Code	Description	Institutional cost
99213	Established patient office/other outpatient visit, 20–29 minutes	\$124
99214	Established patient office/other outpatient visit, 30–39 minutes	\$150
99284	Emergency department visit, level 4	\$688
99285	Emergency department visit, level 5	\$1080

All data were entered into Excel (Microsoft) spreadsheets for data analysis. Data were analyzed using SPSS I27.0BM New York. Statistical analysis was performed using descriptive measures. Cost analysis was based upon institution specific charges associated with CPT codes 99213, 99214, 99284, 99285 (Table 2) and itemized costs of specific interventions, as well as flat fees associated with trauma and surgical service consultation at our institution. The spine department's consultation CPT code of 99213 versus 99214 was simplified to just 99213 for ease of the cost analysis.

Results

Six hundred eighty-two patients with TPF who were admitted to the SLU Trauma Service from January 2012 to August 2018 were identified. Two hundred twenty-eight patients met the criteria to be included in this study. Of these, 477 lumbar TPFs and 103 thoracic TPFs were identified. The mean age of all TPF patients was 45.3 years. 142 patients (62.2%) were men and 86 (37.7%) of patients were female. Average Length of Stay was 9.26±10.5 days. Additional spinal pathology that was not included in the initial radiology report was identified in 5 (2.19%) patients. These included 2 nondisplaced facet fractures (T6 and L3) that were treated nonoperatively, a nondisplaced C7 laminar fracture treated with a rigid cervical orthosis, and T3/4 widening which was suggestive of possible posterior ligamentous injury on a subsequent MRI exam. This patient was treated conservatively with an orthosis. Two patients had questionable spinous process widening that were deemed incidental findings after additional imaging.

No patient had associated neurologic injury or mechanically significant instability requiring operative treatment related to their TPFs or additional spine pathology identified by the spine team. Sixty-four patients (28.1%) with isolated TPF had delayed mobilization due to activity restriction placed because of spine team recommendations initially until "spine clearance" was obtained. Additional diagnostic imaging was requested in 44 patients (19.3%) as a result of the spine consult (average cost \$275.21/patient). Six patients (2.6%) were given an orthosis for comfort to allow improved mobilization, either a Jewitt brace or soft lumbar corset brace (average cost \$163.50/patient). Twenty-one patients (12.2%) were offered clinical follow-up after their hospitalization for their TPF. Four of these patients did not follow up, while 17 patients were seen and released from care after the first visit (Table 3).

Table 3
Demographic data.

Demographic categories	N (%)
Average age	45.3
Male	143 (63%)
Female	85 (37%)
Total TP fractures	477
Thoracic TP fractures	103 (22%)
Lumbar TP fractures	374 (78%)
Average length of stay	9.26 days
Orthoses prescribed	6
Follow-up visits	17

Table 4
Institutional costs of spine interventions.

Intervention	Price (\$)	N	Cost (\$)
OV fee (CPT 22305)	399	172	68,628
MRI C spine w/o contrast	267.19	7	1,870.33
MRI T spine w/o contrast	267.19	2	534.38
MRI L spine w/o contrast	267.19	3	801.57
CT C spine	1,000	2	2,000
CT T spine	1,050	2	2,100
CT L spine	750	3	2,250
Clinic visit level 3	124	18	2,232
XR C spine	75	9	675
XR T spine	150	6	900
XR L spine	100	17	1,700
C collar	69		0
TLSO	259	1	259
Jewitt Brace	256	2	512
Lumbar corset	70	3	210
ED level 3 trauma classification	14,000	228	3,192,000
ED level 3 versus 4 billing difference	392	228	89,376
		Total (\$):	3,366,048.28
		Average cost per patient (\$):	14,763.37

Cost analysis

Spine consultation fees associated with TPFs encompass the spine service charge related to CPT code 99213 which is \$124 at our institution. The emergency department typically elevates their billing when consulting a surgical service from 99284 (\$688) to 99285 (\$1080) which results in an additional \$392 (Table 2). Applying this fee to our total patients results in a total sum of \$89,376. Additionally, our institution typically assigns a level 3 trauma charge of \$14,000 for fracture care related to trauma with surgical consultation for traumatic injuries that do not meet the criteria for level 1 or 2 trauma activation. Applying this fee to our patients totals \$3,192,000. Table 4 enumerates the costs associated with specific interventions along with institution-specific charges pertaining to prescription of braces, clinic follow-up, and additional imaging. Prior to the reimbursement change in 2018, CPT 22305 was also a billable code for \$399 which was applied to 172 patients in this study, totaling \$68,628. Over the course of our study period from 2012 to 2018, additional costs associated with Spine service intervention totals to \$3,366,048.28. Additional cost per patient in our cohort for spine service intervention averages to \$14,763.37 per individual.

Discussion

Isolated thoracic and lumbar spine transverse process fractures were once thought to be rare; however, increased utilization of CT, especially in the trauma setting, have improved sensitivity in the detection of these injuries. TPFs are considered stable fractures that generally do not require surgical intervention. Standard of care treatment of these injuries is conservative and includes pain management and unrestricted mobilization as tolerated [19]. Current management, however, is largely based on clinical experience, rather than evidence, as there is a paucity of literature that details the management of TPF. Nagasawa et al. [20] performed a comprehensive review of the published literature on TPFs which included 4 studies comprised of 398 patients with 819 TPFs. They concluded that nonsurgical management of TPFs leads to complete resolution of the fracture without evidence of permanent neurologic deficit or spinal instability. Bradley et al. [11] conducted a retrospective chart review of 84 patients with transverse process fractures. No patients received surgery or bracing for the treatment of TPFs. Despite these findings, the discovery of these fractures still routinely initiates a consultation to the spine service at many institutions. These consultations are likely driven by many factors, including liability concerns, unfamiliarity with spinal anatomy or biomechanics, or for a “closer look” for additional spinal injuries that may have been missed on the initial radiology imaging report [7].

Our data is the largest patient series to date regarding isolated TPFs, and the first to consider the potential cost of the spine consultation. In this study, no patient who presented with an isolated thoracolumbar transverse process fracture exhibited signs of neurologic injury or mechanical instability. Sixty-four patients (28.1%) had delayed mobilization as a result of spine team precautions put in place until the patient was formally cleared. Typically, these limitations were put in place by the junior house officer overnight at our academic facility prior to senior resident and attending review. This delay in mobilization likely contributed to an increased length of stay in some regard. However, many of the patients included in this study suffered polytrauma and therefore length of stay could not be attributed to their TPFs. Additional spine pathology that was initially missed by the radiology department was identified in 5 patients (2.19%), none of which required operative intervention.

Our cost analysis shows a significant cost associated with Spine service surgical consultation for these isolated thoracolumbar transverse process fractures. On average per patient, \$14,763, 37, is charged to the health care system. Granted, some of these costs could have been avoided by the Spine service, such as offering orthoses for comfort, ordering additional imaging, or offering follow-up etc. However, these specific interventions do not make up the bulk of costs calculated. Billing for surgical consultation in the setting of traumatic injury accounts for roughly 97% of the amount billed in this study. With the current climate of trying to decrease health care expenditures, the cost-benefit of this particular consultation may not be worth it.

This study was limited by its retrospective nature. Costs of treatment interventions vary widely depending on location, institution and the preferences of the attending surgeon provider. The costs included in this study may differ from those at other institutions. The average delay in mobilization with physical therapy could not be calculated due to incomplete notes in the medical record; however, any delay will have gross increase in length of stay. During the course of this study, Spine service standards and the preferences of the attending surgeon on call was variable which led to different treatments, interventions, and follow-up clinic visits offered. Additionally, this study takes place at a large level 1 trauma center which may not be generalizable to smaller institutions without similar capabilities.

Conclusion

These data support that isolated transverse process fractures of the thoracic and lumbar spine are stable injuries that do not require spine service intervention and in fact may represent an unnecessary financial burden. Foregoing unnecessary consultation can alleviate time con-

straints within the spine service practice and the emergency department, while helping to reduce health care costs.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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