Patterns and Trends in Coal Mining Orthopedic Injuries Admitted to a Level One Trauma Center in Southern West Virginia Over Ten Years

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ABSTRACT

There is a paucity of medical literature on patterns of orthopedic injuries sustained by coal mine workers. This manuscript describes patterns of coal mine-related orthopedic injuries among patients admitted to a West Virginia Level 1 trauma hospital over a 10 year period (2005-2014), including patient age and gender, injury type, length of stay, Injury Severity Score, mine location, and prognosis. From 2005 to 2014, 316 patients were admitted with mining-related orthopedic injuries. A statistically significant positive correlation was found between mining-related hospital admissions and tons of coal produced within our hospital’s referral base. Decreased coal production over the study period corresponded to a reduction in coal mine-related orthopedic admissions. Pelvic injuries (9.8% of all orthopedic mine injuries) and finger amputations (7%) were the most common admission types, suggesting that the adoption of better hand protection and amelioration of crush injuries at coal mines could improve miner workplace safety.

INTRODUCTION

Underground coal mining has long been regarded as a dangerous line of work1,2. Mine accidents account for approximately 4 million workplace injuries annually in the United States, which cost American industries and taxpayers at least $170 billion a year3,4. In West Virginia, the issue of mining-related injuries is particularly acute. West Virginia is the nation's second-largest producer of coal, after Wyoming, providing more than 153 million tons per year. Taxation of coal mining companies account for nearly 60 percent of West Virginia's business tax revenue3. In 2014, West Virginia had one of the highest annual workplace injury rates in the United States at 4 injuries per 100 full time workers4. West Virginia, therefore, provides a unique opportunity to investigate trends in mining-related injuries and to specifically explore how modern changes in energy production influence injury rates.

The objective of this study is to investigate patterns in orthopedic injuries admissions over a ten year period at the study trauma center hospital one of three West Virginia trauma centers receiving major mining injuries. While federal reports record fatal coal mine injuries, this is the first study to explore trends in non-fatal orthopedic coal mining injuries2. Furthermore, this study is the first to document how changes in energy production impact mining-related orthopedic injuries.

METHODS

The proposal for this study was presented to the Institutional Review Board and permission was granted for a chart review. All inpatient admissions to our facility with orthopedic injuries sustained at coal mines from January 1, 2005 through December 31, 2014 were included in the study. Emergency room visits that did not result in admission were not included. Patient information was obtained from a chart review and included: age, gender, location (i.e. county) of the coal mine where the injury occurred, mortality, functional disability predictions on discharge, and type of injuries sustained. Functional disability was assessed by the trauma nurse practitioner upon discharge using the Functional
Independence Measure. The Injury Severity Score\(^5\) and length of stay were also noted. Data on annual coal production rates in southern West Virginia were obtained from federal reports\(^6,7\) and were compared to orthopedic injury data described above. Trends in the incidence of specific injury types over the ten year study period were analyzed using Persons Correlation Test. Data were analyzed using SPSS version 22. Comparisons were considered significant for P values less than or equal to 0.05.

RESULTS

316 adults were admitted to our hospital with coal mine related orthopedic injuries during the 10-year study period. This group included a total of 351 orthopedic injuries as some patients had sustained multiple orthopedic injuries. Injury Severity Scores\(^5\) ranged from 1 to 54 with a mean of 8.5 (a major trauma or polytrauma is defined as an Injury Severity Score greater than 15). Most of the injuries in this study were isolated trauma. Only two of the 316 admissions (0.6%) were female. Patient age ranged from 19 to 69 with a mean of 39. The length of hospital stay ranged from one day to 165 days with a mean of 6.4 days. The geographic location (i.e. county) of mining injury sites was available for 197 (62%) of the 316 admission. Boone County, which is adjacent to Kanawha County where our hospital is located, accounted for the greatest number of injuries (82 injuries; 26% of admissions) (Fig. 1). The pattern of transfer of coal mine injuries is no different from the counties of origin of general trauma patients to our facility. Four patients were transported from Kentucky and one was transferred from the West Virginia’s eastern panhandle.

Of 351 recorded orthopedic injuries, 339 (96.6%) resulted from crushing or blunt trauma, nine (2.6%) from penetrating trauma and three (0.9%) from burns. Injuries largely occurred in distal body parts, with 46 fractures occurring in the foot and ankle (14.6%) and 55 (17.4%) in the hand and wrist. Vertebral fractures were present in 44 (12.6%) patients. 23 (7.3%) were compression fractures, 19 (6.0%) were lumbar fractures, and 10 (1.3%) were cervical fractures.

Four deaths (1.1%) occurred following admission for mining-related orthopedic trauma. Pelvic and acetabular fractures and dislocations were the most life-threatening injuries (Table 1). All four of the miner’s deaths were in those who sustained hip and pelvic fractures. 31 (9.8%) pelvic and acetabular injuries were recorded spanning all Young-Burgess pelvic fracture classifications\(^8\). Anterior-posterior compressions (APC) accounted for 11 pelvic fractures, lateral compression for 12, and vertical sheer for one. These findings suggest that most pelvic injuries resulted from crush injuries rather than falls from a height.

22 traumatic amputations (7% of admissions) were operated for stump revision and debridement. Upper extremity amputations predominated. 17 (77% of recorded amputations) were finger amputations: nine single finger amputations, three two finger amputations, one three finger amputation, one fifth ray amputation, and one thumb amputation at the first MCP (metacarpalphalangeal) joint. Only the most severely mangled or contaminated traumatic amputations were included in this study as most partial amputations were treated as outpatients. Lower extremity amputations included one ankle
disarticulation (Symes amputation) and one transmetatarsal amputation. All amputations resulted from crush injuries.

Disability status of 311 patients (98%) was evaluated upon discharge using the Functional Independence Measure scale. The majority of patients (70%) were thought to have a temporary impairment (up to 3 months) with a full recovery expected, 23% were expected to return to full recovery promptly (less that 4 weeks), 6% were classified as moderate disability or likely to have sustained a moderate but permanent impairment and 1% were classified as severe disability or likely to have severe permanent impairment.

A downward trend in mining-related orthopedic injury admissions was observed over the ten-year study period from 40 in 2005 to 11 in 2014 (Fig. 3). This downward trend was consistent across injury types including spinal, hand, and pelvic fractures and traumatic amputations (Fig. 4). Coal production within the study facility’s orthopedic trauma patient catchment area also trended downward over the study period from 111 million tons in 2005 to 62 million tons in 2014 (Fig. 3). A statistically significant correlation was observed between annual coal mine related admissions and tonnage of coal production in southern West Virginia ($r = 0.891, p = 0.001$; Fig. 3).

**DISCUSSION**

The Bureau of Labor Statistics lists mining as one of the most dangerous occupations in the United States\(^2\). Mining injuries are often severe, leaving victims with permanent disabilities, lost wages, costly medical bills and/or psychological distress that affect both miners and their families\(^1\). Nevertheless, coal mining is one of the Appalachian region’s most important industries, with Appalachian miners accounting for 74% of all coal miners in the United States (40,520 employees)\(^9\). Despite extensive federal regulation (including the Federal Coal Mine Health and Safety Act), coal mining continues to be dangerous work\(^2\).

West Virginia produces 12% of all coal mined in the United States and is the nations largest producer of bituminous coal, but the state’s coal production has decreased by 23.5% between 2008 and 2013\(^10\). Much of this downward trend has been driven by decreased production in the southern part of the state. Here, we report a significant correlation between decreased coal production within our hospital’s referral base and a reduction in coal mine-related orthopedic admissions over a ten year period from 2005 to 2014.

Reduced orthopedic mining injuries could be driven by improved mine safety, changes in hospital referral patterns and/or lower risk exposure due to less mining in the region. No major modifications to mine safety laws and regulations were made over the course of the ten year study and no changes in overall trauma transfer patterns were observed. In a review of the number those employed in WV in underground mining during the period reported 2004-2012 revealed actually an increase of 43%\(^11\). Therefore, we posit that the observed decrease in orthopedic mining injuries is the result of lower coal production in the region. If exposure to potentially dangerous mine work environments continues to decline, one may expect further declines in orthopedic workplace injuries.
Reductions in mining-related orthopedic admissions were consistent across injury types (including spinal, hand, and pelvic fractures and traumatic amputations), but the overwhelming majority orthopedic mining injuries were caused by crushing. In addition, continual changes in technology and the improvements in the infrastructures built with modern technology the injury rates could decline further.

CONCLUSIONS

We observed a significant correlation between decreased coal production and admission rates for orthopedic trauma mining injuries at our orthopedic trauma center in southern West Virginia. While care should be taken to avoid potentially confusing correlation and causation, this observation may have significant implications for mine safety and suggests that changes in energy production could influence local medical support requirements.

Since the majority of orthopedic mining injuries occurring to the hands and the feet, improved personal protective equipment for the extremities and/or improved safety practices to reduce these types of injuries should yield better workplace safety. Additionally, the prevalence of crushing injuries suggests that improved protection from falling coal and/or equipment could further reduce mining injury rates.

Although coal mining is considered one of the nation’s most dangerous occupations, it is our hope that the information presented in this study can help make mines safer. Furthermore, our findings suggest that as trends in energy production change, so will the medical support systems required to support them.
REFERENCES

1. Page, Karen, Blood on the coal: The effect of organizational size and differentiation on coal mine accidents, University of Wyoming College of Business, 1000 East University Avenue, Department 3275, Laramie, WY 82071, USA


Figure 1. Map of location of injuries by county.
Figure 2. Anatomic locations of orthopedic injuries reported in this study. Numbers indicate the frequency of injuries at specific locations as indicated by black arrows. Numbers on the left indicate fractures while those on the right indicate dislocations.
Figure 3. Coal production in the trauma center’s catchment area (red) and coal mine injury admissions to our facility (blue) by year.
Figure 4. Coal mine injury admissions by year and fracture type.
Table 1. Young-Burgess classification of pelvic and acetabular fracture patterns. Pelvic fractures are further classified by fracture type (i.e. anterioposterior compression [APC], lateral compression [LC] or vertical shear [VS]).

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