Trauma Surgery & Acute Care Open

Defining severe traumatic brain injury readmission rates and reasons in a rural state

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Received 16 April 2018
Revised 2 August 2018
Accepted 6 August 2018

To cite: Gardner J, Sexton KW, Taylor J, *et al*. *Trauma Surg Acute Care Open* 2018;**3**:e000186.

ABSTRACT

Background Readmissions after a traumatic brain injury (TBI) have significant impact on long-term patient outcomes through interruption of rehabilitation. This study examined readmissions in a rural population, hypothesizing that readmitted patients after TBI will be older and have more comorbidities than those not readmitted.

Methods Discharge data on all patients 15 years and older who were admitted to an Arkansas-based hospital for TBI were obtained from the Arkansas Hospital Discharge Data System from 2010 to 2014. This data set includes diagnoses (principal discharge diagnosis, up to 3 external cause of injury codes, 18 diagnosis codes using the International Classification of Disease, 9th Edition, Clinical Modifications), age, gender, and inpatient costs. Hospital Cost and Utilization Project Clinical Classification and Chronic Condition Indicator were used to identify chronic disease and body systems affected in principal diagnosis.

Results Of the 3114 cases of significant head trauma, more than two-thirds were attributed to fall injuries, with motor vehicle crashes accounting for 20% of the remainder. The mean length of stay was 6.5 days. 691 of these patients were admitted to an Arkansas hospital in the following year, totaling 1368 readmissions. Of the readmissions, 16.4% of patients were admitted for altered mental status, 12.9% with shortness of breath (SOB), and 9.4% with chest pain. Mental disorders (psychosis, dementia, and depression) and organic nervous symptoms (Alzheimer's disease, encephalopathy, and epilepsy) were the primary source of readmissions. More than one-third of the patients were admitted in the following year for chronic diseases such as heart failure (8.6%), psychosis (5.2%), and cerebral artery occlusion (4.1%).

Discussion This study showed that there is a significant rate of readmissions in the year after a diagnosis of TBI. Complications with existing chronic diseases are among the most reported reasons for admission in this time period, demonstrating the effect severe head trauma has on long-term treatment.

Level of evidence Level IV, Retrospective epidemiological study.

BACKGROUND

Traumatic brain injury (TBI) is a major public health concern given the socioeconomic impact it has on patients and their families, especially in an overall aging population. Close to 1.7 million TBIs are suffered every year in the USA.[1] It has been shown that TBIs occur at a higher incidence and are associated with a higher mortality in rural populations compared with urban/metropolitan areas.[2] However, this has been shown more convincingly in pediatric and international populations compared with adult populations in the USA. TBIs are also associated with a high readmission rate in postincident follow-up, both short and long term.[3 4] A major factor in morbidity and mortality after sustaining a TBI is appropriate care of the acute injury. Inability to transport to a level 1 trauma center in a timely manner is a common source of this delay to appropriate care. These delays are more likely to happen in populations with limited access to higher level trauma centers, a situation common in rural areas. Prior studies have shown that rapid transport to these centers improves outcomes for patients who have experienced a TBI.[5]

The advent of electronic medical records (EMR) should have made available large sets of data that could be analyzed to better inform treatment decisions to improve patient outcomes. However, integration of different EMR systems and data sets has not always proven to be an easy task. Lack of standardization is a major obstacle to medical research using these systems as databases. Unfortunately, in the USA there are no national registries or EMR systems in which to pool and standardize data, but Canada has such a system, which more easily allows for large-scale population-based studies with more standardized patient data to be performed much more easily.[4 6 7] This highlights the need for further research into TBIs in rural populations using standardized systems from which to extract patient data for analysis.

The aim of this study was to examine a statewide trauma system via a data repository to pool data on readmission rates in adults who suffered TBIs. This system allows standardization across the patient population. Arkansas is a predominately rural state served by one centrally located level 1 trauma center in the state, and has a centralized trauma system allowing the data repository to catalog the vast majority of TBIs that occur in the state. Therefore, Arkansas is an ideal population in which to investigate the rates and reasons for readmissions in rural patients who have experienced a TBI. We hypothesize that readmitted patients after TBI will be older and have more comorbidities than those not readmitted.

METHODS

Data source

Data were obtained from the Arkansas Hospital Discharge Data System (HDDS) from 2010 to 2014.

Stored and maintained at the Arkansas Department of Health, the HDDS is an administrative data set containing information on all hospital discharges from Arkansas' acute care hospitals. This data set includes diagnoses (principal discharge diagnosis, up to 3 external cause of injury codes, 18 diagnosis codes using the International Classification of Disease, 9th Edition, Clinical Modifications (ICD-9-CM)), age, gender, and inpatient costs. Inpatient costs were adjusted to 2013 dollars using the medical care model for the Consumer Price Index for All Urban Consumers.[1 2]

The HDDS was analyzed using ICD-mapping software that would provide the researchers with corresponding Injury Severity Scores (ISS) and Abbreviated Injury Scale (AIS) scores. This technique has been used in several studies that have used the diagnoses codes in administrative data sets to assign patients with ISS and AIS scores.[3–5]

Case definition

All patients 15 years and older who were admitted to an Arkansas-based hospital for a TBI were identified. The Centers for Disease Control and Prevention definitions for TBI were used to identify patients using the ICD-9 codes: 800.0–801.9, 803.0–804.9, 850.0–854.1, 950.1–950.3, or 959.01.[6] Due to the broad case definition of TBI, only patients who were identified with significant head trauma (SHT) were used in the analysis. SHT was identified by the presence of any of the following ICD-9 codes in any of the 18 diagnosis fields: 852.0–852.59 (subarachnoid, subdural, and extradural hemorrhage following injury) or 853.0–853.19 (other and unspecified intracranial hemorrhage following injury).

Data linkage

Patient identifiers such as first and last name, date of birth, and gender were used to link all inpatient records in the database for one full year after an SHT, using the probabilistic linkage software, LinkageWiz.

Diagnosis classification

The Hospital Cost and Utilization Project (HCUP) Clinical Classification and Chronic Condition Indicator (CCI) tools were used to group diagnosis codes. Hospital admissions in the year after the initial SHT were classified using these tools based on the principal diagnosis only. The HCUP tools allowed for the identification of chronic diseases and the body systems that were impacted based on the principal diagnosis.

RESULTS

Initial hospitalization demographics

Table 1 demonstrates that during the study years 2010 to 2014, there were 3114 hospital admissions where the patient was diagnosed with an SHT. The mean age of those admitted was 67.3 years and men attributed to 52.2% of this population. The mean ISS during the initial hospital admission was 17.3, with 288 (9.3%) inpatient deaths. More than two-thirds of the initial admissions were attributed to unintentional falls. Motor vehicle crashes (MVCs) accounted for more than 20% of the initial admissions involving SHT. The mean hospital length of stay was 6.5 days. The mean and median adjusted hospital costs associated with these admissions were $13 955.65 and $7000.35, respectively. The inpatient costs for these admissions totaled more than $43 million.

Table 1 Patient demographics

Variable	N=3114
Male	1624 (52.2%)
Age, mean (SD)	67.3 (20.7)
ISS	
9–15	480 (15.4%)
16–24	2246 (72.2%)
≥25	385 (12.4%)
ISS, mean (SD)	17.3 (5.6)
Hospital length of stay, mean (SD)	6.5 (8.2)
Adjusted medical costs	$13 955.65 ($20 728)
Comorbidities present	
0	479 (15.4%)
1	642 (20.6%)
2	696 (22.4%)
3+	1297 (41.7%)
Injury mechanism	
Fall	2077 (66.7%)
MVC	667 (21.4%)
Other	221 (7.1%)
Assault	124 (4.0%)
Self-inflicted	25 (0.8%)
Disposition status	
Home	1573 (50.6%)
Outpatient rehabilitation facility	530 (17.0%)
Skilled nursing facility	439 (14.1%)
Died	302 (9.7%)
Transferred	224 (7.2%)
Intermediate care facility	44 (1.4%)

ISS, Injury Severity Score; MVC, motor vehicle crash.

Readmissions after SHT

Among the 3114 SHT-related inpatient admissions, there were 691 patients who were admitted to an Arkansas-based hospital for any reason in the following year. These 691 patients resulted in 1368 all-cause admissions in the year after the initial inpatient stay due to SHT.

Table 2 shows the mean age of the patients who were readmitted in the following year was 71.1 years and 48.9% of the readmissions were men. The mean and median adjusted hospital costs were $13 259.04 and $6890.55, respectively. The sum of the costs for the readmissions was $9.2 million.

Table 3 presents the impacted body system based on the principal diagnosis. Broadly termed diagnoses such as altered mental status (n=56; 16.4%), shortness of breath (n=44; 12.9%), and chest pain (n=32; 9.4%) accounted for the leading three diagnoses for this grouping. Other diagnosis included in this grouping were syncope (n=28; 8.2%), fatigue (n=27; 7.9%), and stupor (n=27; 7.9%). Some of the notable body systems that were impacted were mental disorders and nervous systems, which accounted for 8.6% and 3.6% of the readmissions, respectively. Mental health disorders such as psychosis (n=24; 20.3%), dementia (n=14; 11.9%), and depression (n=11; 9.3%) were the leading diagnoses in this grouping. The leading diagnoses that impacted the nervous system were Alzheimer's disease (n=15; 30.6%), encephalopathy (n=5; 10.2%), and epilepsy (n=5; 10.2%).

Table 2 Comparative descriptive statistics for patients readmitted with those who were not

Variable	Not readmitted (n=2423)	Readmitted (n=691)	P values
Male	1286 (53.1%)	338 (48.9%)	0.05
Age, mean (SD)	66.2 (21.5)	71.1 (17.0)	<0.0001
ISS			
9–15	376 (15.5%)	104 (15.1%)	0.76
16–24	1705 (70.4%)	541 (78.3%)	<0.0001
≥25	340 (14.0%)	45 (6.5%)	<0.0001
ISS, mean (SD)	17.5 (5.9)	16.6 (4.5)	<0.0001
Hospital length of stay, mean (SD)	6.4 (8.2)	6.7 (7.9)	0.33
Adjusted medical costs	$14 154.30 ($21 318)	$13 259.00 ($18 506)	0.28
Comorbidities present			
0	419 (17.3%)	60 (8.7%)	<0.0001
1	526 (21.7%)	116 (16.8%)	0.005
2	531 (21.9%)	165 (23.9%)	0.27
3+	947 (39.1%)	350 (50.7%)	<0.0001
Injury mechanism			
Fall	1563 (64.5%)	514 (74.4%)	<0.0001
MVC	559 (23.1%)	108 (15.6%)	<0.0001
Other	171 (7.1%)	50 (7.2%)	0.87
Assault	108 (4.5%)	16 (2.3%)	0.01
Self-inflicted	22 (0.9%)	3 (0.4%)	0.22
Disposition status			
Home	1250 (51.6%)	323 (46.7%)	0.02
Rehab	380 (15.7%)	150 (21.7%)	0.0002
Skilled nursing facility	288 (11.9%)	151 (21.9%)	<0.0001
Died	NA	NA	
Transferred	180 (7.4%)	44 (6.4%)	0.34
Intermediate care facility	27 (1.1%)	17 (2.5%)	0.008

ISS, Injury Severity Score; MVC, motor vehicle crash; NA, not available.

Table 3 Body system impacted 1 year after significant head trauma

Body system	Frequency	Percent
Symptoms, signs, ill-defined conditions	341	24.9
Circulatory system	210	15.3
Respiratory system	136	9.9
Mental disorders	118	8.6
Injury and poisoning	113	8.3
Digestive system	86	6.3
Genitourinary system	77	5.6
Musculoskeletal system	60	4.4
Nervous system	49	3.6
Factors influencing health status	47	3.4
Infectious diseases	41	3.0
Endocrine and metabolic diseases	37	2.7
Neoplasm	17	1.2
Diseases of blood-forming organs	15	1.1
Skin and subcutaneous tissues	14	1.0
Complications of pregnancy	7	0.5
Congenital	1	0.1

Table 4 Chronic disease indicator

Chronic disease	Frequency	Percent
Yes	463	33.8
No	906	66.2

According to table 4, more than one-third of the patients were admitted the following year due to chronic diseases, as determined by the HCUP CCI tool. Congestive heart failure (n=40; 8.6%), psychosis (n=24; 5.2%), and occlusion of the cerebral arteries (n=19; 4.1%) were among the most frequent chronic diseases that resulted in a hospital admission in the year after SHT.

DISCUSSION

This study of TBI readmission rates in a predominately rural-based population showed a 22% readmission rate during the year after the initial TBI incident. Most of the patients who were readmitted were older than 70 years old, with a close to even split of men and women. As with other reported statistics on the causes of TBIs, the majority of cases were attributed to falls, followed by MVCs, which were the second leading cause.[1] Altered mental status, shortness of breath, and chest pain were the three leading diagnoses in the group of readmitted patients, followed by syncope, fatigue, and stupor. Mental disorders and nervous system complaints were also notable in these patients. Psychosis, dementia, and depression were notable mental disorders, whereas Alzheimer's disease, encephalopathy, and epilepsy were the major nervous system diagnoses. Chronic diseases such as congestive heart failure, psychosis, and cerebral artery occlusion accounted for the most chronic disease-related readmissions, respectively.

Interestingly, potential cardiovascular complaints accounted for the second highest reason for readmission in the year after SHT and as the highest potential chronic disease-related readmission. This is notable for the role that autonomic dysreflexia could play in the chronic management of patients with TBIs.[8] Disruption of control of the cardiovascular system can manifest in many ways: hypertension, bradycardia, and abnormal cardiac contractility are possible after TBI. A high index of suspicion for autonomic dysreflexia is important in this patient population as a driving force of cardiovascular pathology.[8]

Readmission from a rehabilitation center accounted for a significant percentage of all readmissions. Published statistics suggest that high readmission rates from rehabilitation centers in patients with TBIs are to be expected to some extent. Factors affecting readmission include surgical, medical, and psychological. Patients who had impaired consciousness are more likely to require hospital readmission.[9–11] Medical factors suggest that some level of intervention or surveillance may decrease readmission. Cardiovascular complaints and infection (urinary tract infection/pulmonary) were major causes of readmission from a rehabilitation center. Whereas cardiovascular complications were seen in the overall readmission population, infection was not a significant reason for readmission. These factors suggest that surveillance and management of either pre-existing cardiovascular comorbidities or newly developed cardiovascular complaints can have an effect on readmission rates. Also, measures to decrease the incidence of urinary tract infection and respiratory infection can have an effect on readmission and cost of care.[10–12]

Limitations

As a retrospective study, there are limitations in our data quality. Our data are limited to administrative data and can be biased by coding errors. Our data cannot account for confounding variables including, but not limited to, financial and educational factors affecting readmission. We did not collect baseline health data or admission data prior to the TBI; thus, we cannot extrapolate if the readmission rates are impacted by certain baseline health characteristics. Additionally, our data would not capture patients admitted in another state, and this could impact our measured outcomes on patients living close to the state border.

Future directions

This study highlights the fact that TBIs are an important medical issue for people in rural populations as well as for the medical and payor systems caring for those patients. Future studies are needed of a larger scale population in the USA. Furthermore, a lack of baseline health statistics on patients who suffer TBIs affects the ability to draw conclusions about the role TBIs play in potential chronic diseases and needs to be studied. Prospectively, we need to collect outcomes on patients to fully understand how TBIs affect the outcomes of patients in chronic disease states and what direct effects TBIs have in these processes.

Contributors All individuals listed as authors of this review article have participated in its drafting, conceptualizing the research or content of the article, and in writing or critically editing the article.

Funding The project described was supported by the Translational Research Institute (TRI) (grant 1U54TR001629-01A1) through the National Center for Advancing Translational Sciences of the National Institutes of Health (NIH). The content is solely the responsibility of the authors and does not necessarily represent the official views of the NIH. KWS is supported by the UAMS Clinician Scientist Program.

Competing interests None declared.

Patient consent Not required.

Ethics approval UAMS.

Provenance and peer review Not commissioned; externally peer reviewed.

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