Neurospine 2021;18(4):786-797.
https://doi.org/10.14245/ns.2142712.356

Neurospine
pISSN 2586-6583 eISSN 2586-6591

Original Article

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Received: July 12, 2021
Revised: September 1, 2021
Accepted: October 13, 2021

Spinal Fractures in Ankylosing Spondylitis: Patterns, Management, and Complications in the United States – Analysis of Latest Nationwide Inpatient Sample Data

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Objective: Ankylosing spondylitis (AS) is a rheumatic inflammatory disease marked by chronic inflammation of the axial skeleton. This condition, particularly when severe, can lead to increased risk of vertebral fractures attributed to decreased ability of the stiffened spinal column to sustain normal loads. However, little focus has been placed on understanding the locations of spinal fractures and associated complications and assessing the correlation between these. In this review, we aim to summarize the complications and treatment patterns in the United States in AS patients with spinal fractures, using the latest Nationwide Inpatient Sample (NIS) database (2016–2018).
Methods: We analyzed the NIS data of years 2016–2018 to compare the fracture patterns and complications.
Results: A total of 5,385 patients were included. The mean age was 71.63 years (standard deviation [SD], 13.21), with male predominance (83.8%). The most common population is Whites (77.4%), followed by Hispanics (7.9%). The most common fracture level was thoracic level (58.3%), followed by cervical level (38%). Multiple fracture levels were found in 13.3% of the patients. Spinal cord injury (SCI) was associated with 15.8% of the patients. The cervical level had a higher proportion of SCI (26.5%), followed by thoracic level (9.2%). The mean Elixhauser comorbidity score was 4.82 (SD, 2.17). A total of 2,365 patients (43.9%) underwent surgical treatment for the fractures. The overall complication rate was 40.8%. Respiratory complications, including pneumonia and respiratory insufficiency, were the predominant complications in the overall cohort. Based on the regression analysis, there was no significant difference ($p = 0.45$) in the complication rates based on the levels. The presence of SCI increased the odds of having a complication by 2.164 times (95% confidence interval, 1.722–2.72; $p \leq 0.001$), and an increase in Elixhauser comorbidity score predicted the complication and in-hospital mortality rate ($p \leq 0.001$).
Conclusion: AS patients with spinal fractures have higher postoperative complications than the general population. The most common fracture location was thoracic in our study, although it differs with few studies, with SCI occurring in 1/6th of the patients.

Keywords: Ankylosing spondylitis, Spinal fractures, Respiratory complications, National Inpatient Sample

INTRODUCTION

Ankylosing spondylitis (AS) is a rheumatic disorder marked by chronic inflammation of the axial skeleton.[1] It is a relatively rare disease with an incidence of 0.5–14 per 100,000 people per year.[2] This condition, particularly when severe, can lead to increased risk of vertebral fractures attributed to decreased ability of the stiffened spinal column to sustain normal loads (decreased tensile strength of the spine as a unit).[3] A population-based study reported an odds ratio of 7.7 for sustaining a spinal fracture in patients with AS compared to the average population. With each year of increasing age, a 1.3% risk of having a fracture is added.[3] The reported prevalence of spinal fractures in AS patients is highly variable (1.4%–58%). Spinal trauma literature details a 6%–11% mortality rate in AS patients who underwent hospitalization for traumatic spinal fracture.[4] Spinal cord injury (SCI) is a severe complication after traumatic fracture of the ankylosed spine.[2,5] A Finnish national study reported the incidence of SCI in AS patients 11.4 times more than the average population.[6]

The etiology behind vertebral fractures in AS patients stems from inflamed facet joints and ligaments and stiffened intervertebral spaces, resulting in decreased spinal column flexibility.[1] The classic "bamboo spine" develops with even marginal syndesmophyte formation, contributing to compromised bone integrity (Fig. 1).[7] Literature advocates comprehensive spinal imaging in AS patients who suffer from even mild trauma to ensure fractures are not overlooked. However, little focus has been placed on understanding the locations of spinal fractures and postfracture complications and the correlation between these. The extra-articular manifestations in AS affect the other systems (cardiovascular, respiratory, and renal, etc.), further complicating the postoperative course. In this review, we aim to summarize the complications and treatment patterns in the United States in AS patients with spinal fractures, using the latest Nationwide Inpatient Sample (NIS) database (2016–2018).

MATERIALS AND METHODS

1. Study Population

Data were extracted from the NIS database for the years 2016–2018 (3 years). NIS data is the largest database providing data of more than 7 million hospitalizations in the United States. The data is coded in the form of diagnostic and procedural International Statistical Classification of Diseases, 10th revision (ICD-10) codes.

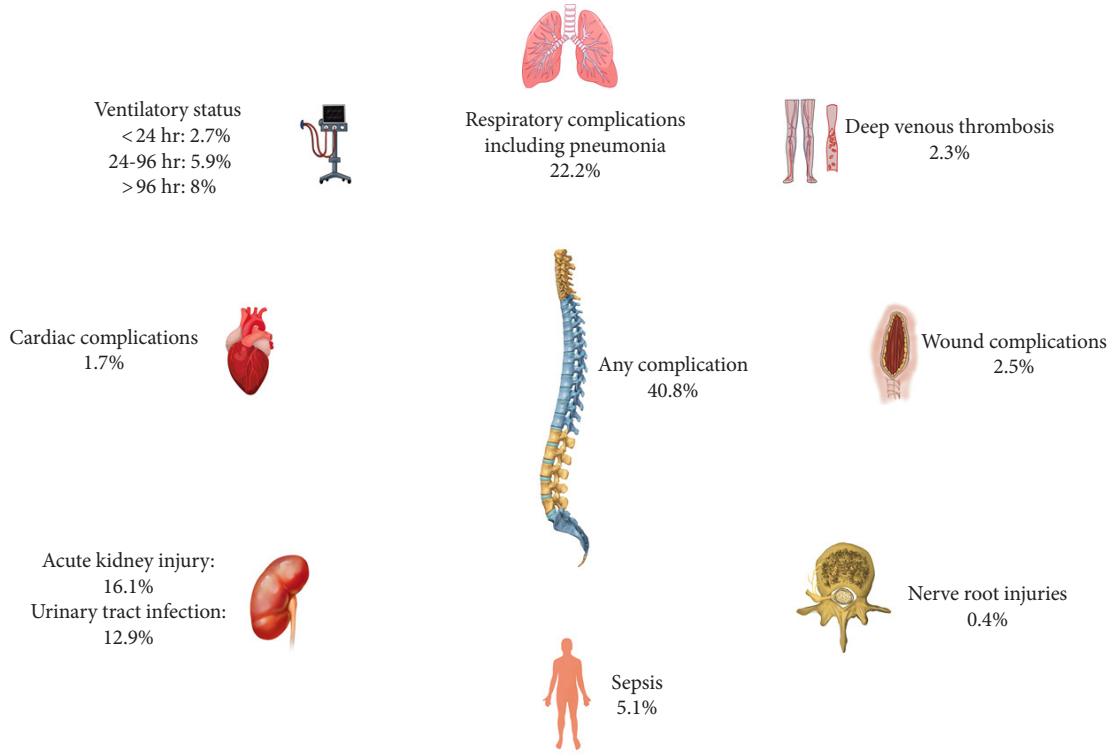

Fig. 1. Pathogenesis involved in ankylosing spondylitis.

Table 1. Details of the ICD-10 codes used for data extraction

Diagnosis	ICD-10 code
Ankylosing spondylitis	M45.(1-9)
Cervical fractures and dislocations	Base codes: S12.0(X), S12.1(X), S12.2X, S12.3(X), S12.4(X), S12.5(X), S12.6(X), S12.8(X), S12.9(X)
Thoracic fractures and dislocations	Base codes: S22.00(x), S22.01(x), S22.02(x), S22.03(x), S22.04(x), S22.05(x), S22.06(x), S22.07(x), S22.08(x)
Lumbar fracture	Base codes: S32.00(x), S32.01(X), S32.02(X), S32.03(X), S32.04(X), S32.05(X)
Sacral level	Base codes: S32.11(X), S32.12(X), S32.13(X), S32.14(X), S32.15(X), S32.16(X), S32.17(X), S32.19(X)
Spinal cord injury	S14(X), S24(X), S34(X)
Fusion	0RG0070,0RG0071,0RG007J,0RG00A0,0RG00AJ,0RG00J0,0RG00J1,0RG00JJ,0RG00K0,0RG00K1,0RG00KJ,0RG0370,0RG0371,0RG037J,0RG03A0,0RG03AJ,0RG03J0,0RG03J1,0RG03JJ,0RG03K0,0RG03K1,0RG03KJ,0RG0470,0RG0471,0RG047J,0RG04A0,0RG04AJ,0RG04J0,0RG04J1,0RG04JJ,0RG04K0,0RG04K1,0RG04KJ,0RG1070,0RG1071,0RG107J,0RG10A0,0RG10AJ,0RG10J0,0RG10J1,0RG10JJ,0RG10K0,0RG10K1,0RG10KJ,0RG1370,0RG1371,0RG137J,0RG13A0,0RG13AJ,0RG13J0,0RG13J1,0RG13JJ,0RG13K0,0RG13K1,0RG13KJ,0RG1470,0RG1471,0RG147J,0RG14A0,0RG14AJ,0RG14J0,0RG14J1,0RG14JJ,0RG14K0,0RG14K1,0RG14KJ,0RG2070,0RG2071,0RG207J,0RG20A0,0RG20AJ,0RG20J0,0RG20J1,0RG20JJ,0RG20K0,0RG20K1,0RG20KJ,0RG2370,0RG2371,0RG237J,0RG23A0,0RG23AJ,0RG23J0,0RG23J1,0RG23JJ,0RG23K0,0RG23K1,0RG23KJ,0RG2470,0RG2471,0RG247J,0RG24A0,0RG24AJ,0RG24J0,0RG24J1,0RG24JJ,0RG24K0,0RG24K1,0RG24KJ,0RG4070,0RG4071,0RG407J,0RG40A0,0RG40AJ,0RG40J0,0RG40J1,0RG40JJ,0RG40K0,0RG40K1,0RG40KJ,0RG4370,0RG4371,0RG437J,0RG43A0,0RG43AJ,0RG43J0,0RG43J1,0RG43JJ,0RG43K0,0RG43K1,0RG43KJ,0RG4470,0RG4471,0RG447J,0RG44A0,0RG44AJ,0RG44J0,0RG44J1,0RG44JJ,0RG44K0,0RG44K1,0RG44KJ,0RG6070,0RG6071,0RG607J,0RG60A0,0RG60AJ,0RG60J0,0RG60J1,0RG60JJ,0RG60K0,0RG60K1,0RG60KJ,0RG6370,0RG6371,0RG637J,0RG63A0,0RG63AJ,0RG63J0,0RG63J1,0RG63JJ,0RG63K0,0RG63K1,0RG63KJ,0RG6470,0RG6471,0RG647J,0RG64A0,0RG64AJ,0RG64J0,0RG64J1,0RG64JJ,0RG64K0,0RG64K1,0RG64KJ,0RG7070,0RG7071,0RG707J,0RG70A0,0RG70AJ,0RG70J0,0RG70J1,0RG70JJ,0RG70K0,0RG70K1,0RG70KJ,0RG7370,0RG7371,0RG737J,0RG73A0,0RG73AJ,0RG73J0,0RG73J1,0RG73JJ,0RG73K0,0RG73K1,0RG73KJ,0RG7470,0RG7471,0RG747J,0RG74A0,0RG74AJ,0RG74J0,0RG74J1,0RG74JJ,0RG74K0,0RG74K1,0RG74KJ,0RG8070,0RG8071,0RG807J,0RG80A0,0RG80AJ,0RG80J0,0RG80J1,0RG80JJ,0RG80K0,0RG80K1,0RG80KJ,0RG8370,0RG8371,0RG837J,0RG83A0,0RG83AJ,0RG83J0,0RG83J1,0RG83JJ,0RG83K0,0RG83K1,0RG83KJ,0RG8470,0RG8471,0RG847J,0RG84A0,0RG84AJ,0RG84J0,0RG84J1,0RG84JJ,0RG84K0,0RG84K1,0RG84KJ,0SG0070,0SG0071,0SG007J,0SG00A0,0SG00AJ,0SG00J0,0SG00J1,0SG00JJ,0SG00K0,0SG00K1,0SG00KJ,0SG0370,0SG0371,0SG037J,0SG03A0,0SG03AJ,0SG03J0,0SG03J1,0SG03JJ,0SG03K0,0SG03K1,0SG03KJ,0SG0470,0SG0471,0SG047J,0SG04A0,0SG04AJ,0SG04J0,0SG04J1,0SG04JJ,0SG04K0,0SG04K1,0SG04KJ,0SG1070,0SG1071,0SG107J,0SG10A0,0SG10AJ,0SG10J0,0SG10J1,0SG10JJ,0SG10K0,0SG10K1,0SG10KJ,0SG1370,0SG1371,0SG137J,0SG13A0,0SG13AJ,0SG13J0,0SG13J1,0SG13JJ,0SG13K0,0SG13K1,0SG13KJ,0SG1470,0SG1471,0SG147J,0SG14A0,0SG14AJ,0SG14J0,0SG14J1,0SG14JJ,0SG14K0,0SG14K1,0SG14KJ,0SG3070,0SG3071,0SG307J,0SG30A0,0SG30AJ,0SG30J0,0SG30J1,0SG30JJ,0SG30K0,0SG30K1,0SG30KJ,0SG3370,0SG3371,0SG337J,0SG33A0,0SG33AJ,0SG33J0,0SG33J1,0SG33JJ,0SG33K0,0SG33K1,0SG33KJ,0SG3470,0SG3471,0SG347J,0SG34A0,0SG34AJ,0SG34J0,0SG34J1,0SG34JJ,0SG34K0,0SG34K1,0SG34KJ,0SG5070,0SG5071,0SG507J,0SG50A0,0SG50AJ,0SG50J0,0SG50J1,0SG50JJ,0SG50K0,0SG50K1,0SG50KJ,0SG5370,0SG5371,0SG537J,0SG53A0,0SG53AJ,0SG53J0,0SG53J1,0SG53JJ,0SG53K0,0SG53K1,0SG53KJ,0SG5470,0SG5471,0SG547J,0SG54A0,0SG54AJ,0SG54J0,0SG54J1,0SG54JJ,0SG54K0,0SG54K1,0SG54KJ,0SG6070,0SG6071,0SG607J,0SG60A0,0SG60AJ,0SG60J0,0SG60J1,0SG60JJ,0SG60K0,0SG60K1,0SG60KJ,0SG6370,0SG6371,0SG637J,0SG63A0,0SG63AJ,0SG63J0,0SG63J1,0SG63JJ,0SG63K0,0SG63K1,0SG63KJ,0SG6470,0SG6471,0SG647J,0SG64A0,0SG64AJ,0SG64J0,0SG64J1,0SG64JJ,0SG64K0,0SG64K1,0SG64KJ
Corpectomy	0P540ZZ,0P840ZZ,0PB40ZX,0PB40ZZ,0PC40ZZ,0PD40ZZ,0PH404Z,0PN40ZZ,0PR407Z,0PR40JZ,0PR40KZ,0PU407Z,0PU40JZ,0PU40KZ,0R560ZZ,0RB60ZX,0RB60ZZ,0RC90ZZ,0RG6070,0RG607J,0RG60A0,0RG60AJ,0RG60Z0,0RG60JJ,0RG60K0,0RG60KJ,0RH604Z,0RH608Z,0RR607Z,0RR60JZ,0RR60KZ,XRG6092,XRG60F3,XRG7092,XRG70F3,XRG8092,XRG80F3,0Q500ZZ,0Q800ZZ,0QB00ZX,0QB00ZZ,0QC00ZZ,0QD00ZZ,0QH004Z,0QH005Z,0QN00ZZ,0QR007Z,0QR00JZ,0QR00KZ,0QS004Z,0QS00ZZ,0QS0XZZ,0QU007Z,0QU00JZ,0QU00KZ,0S500ZZ,0SB00ZX,0SB00ZZ,0SC00ZZ,0SG0070,0SG007J,0SG00A0,0SG00AJ,0SG00J0,0SG00JJ,0SG00K0,0SG00KJ,0SH004J,0SH008Z,0SN00ZZ,0SR007Z,0SR00JZ,0SR00KZ,0SU007Z,0SU00JZ,0SU00KZ,0P530ZZ,0P830ZZ,0PB30ZX,0PB30ZZ,0PC30ZZ,0PD30ZZ,0PH304Z,0PN30ZZ,0PR307Z,0PR30JZ,0PR30KZ,0PU307Z,0PU30JZ,0PU30KZ,0R500ZZ,0RB00ZX,0RB00ZZ,0RB10ZX,0RB10ZZ,0RC00ZZ,0RC10ZZ,0RG0070,0RG0071,0RG007J,0RG00A0,0RG00AJ,0RG00J0,0RG00JJ,0RG00K0,0RG00KJ,0RG1070,0RG107J,0RG10A0,0RG10AJ,0RG10J0,0RG10JJ,0RG10K0,0RG10KJ,0RH004Z,0RR007Z,0RR00JZ,0RR00KZ,0RR107Z,0RR10JZ,0RR10KZ,0RU007Z,0RU00ZJ,0RU00KZ,0RU107Z,0RU10JZ,0RU10KZ,XRG0092,XRG00F3,XRG1092,XRG10F3

(*Continued*)

https://doi.org/10.14245/ns.2142712.356

Table 1. Details of the ICD-10 codes used for data extraction (continued)

Diagnosis	ICD-10 code
Wound complications, including CSF leak	T81.3,T81.30,T81.30XA,T81.30XD,T81.30XS,T81.31,T81.31XA,T81.31XD,T81.31XS,T81.32,T81.32XA,T81.32XD, T81.32XS, G97.0
Respiratory complications	J81.0,J80,J96.00,J96.90,J96.91,J96.92,J96.01,J96.02,J95.89,J95.859,T8.182XA,J18,J18.0,J18.1,J18.2,J18.8,J18.9
Acute Kidney Injury	N17.0,N17.1,N17.2,N17.8,N17.9
UTI	N39.0
Cardiac complications	197.710, I97.790, I97.88, I97.89
Nerve root injuries	S14.2(X), S24.2(X), S34.2(X)
Sepsis and septic shock	A410,A4101,A4102,A411,A412,A413,A414,A415,A4150,A4151,A4152,A4153,A4159,A418,A4181,A4189,A419, T81.12, T81.12XA, T81.12XD, T81.12XS
Ventilation	5A1935Z, 5A1945Z, 5A1955Z
DVT	I82.2(X)

ICD-10, International Statistical Classification of Diseases, 10th revision; CSF, cerebrospinal fluid; UTI, urinary tract infection; DVT, deep venous thrombosis.

2. Inclusion Criteria

(1) All patients with AS and spinal fractures, (2) Spinal fractures as a primary cause of admission, age > 18 years.

3. Exclusion Criteria

Spinal fractures are not a primary cause of admission.

4. Data Extraction

The data was extracted from the NIS data based on the ICD-10 diagnostic and procedural codes. NIS data provides weighted frequencies allowing to extrapolate national estimates. The diagnostic and procedural codes used to extract AS, spinal fractures at various levels, and complications of the surgical treatment were detailed in Table 1. The data were grouped based on the fracture level (i.e., cervical, thoracic, etc.).

The patient-level comorbidities were extracted based on the Elixhauser comorbidity algorithm[8] provided on the Healthcare Cost and Utilization Project website (https://www.hcup-us.ahrq.gov/nisoverview.jsp). Along with these variables, patient-level factors like race, socioeconomic characteristics, location of the patient, and hospital and patient's zip code's median income were also analyzed and described in the descriptive fashion. Complications were calculated for the patients who underwent surgical treatment.

5. Statistical Analysis

All variables were described in a standard descriptive fashion. Continuous variables are described as mean, standard deviation (SD), and median as appropriate and categorical variables as frequencies. Logistic regression analysis was used to calculate the odds ratios for the mutually exclusive levels and probability of the complications after adjusting for the SCI, Elixhauser comorbidities score and used Wald statistics to test the differences between them. Statistical significance was considered if the p-value (2-tailed) is 0.05. NIS discharge weights were used to extrapolate at the national level. All the analysis was performed using IBM SPSS Statistics ver. 27.0 (IBM Co., Armonk, NY, USA).

RESULTS

1. Clinical Characteristics

1) Overall patient cohort

A total of 5,385 patients were included. The mean age was 71.63 years (SD, 13.21), with male predominance (83.8%). The most common population is Whites (77.4%), followed by Hispanics (7.9%). The most common fracture level was thoracic level (58.3%), followed by cervical level (38%). Multiple fracture levels were found in 13.3% of the patients. SCI was associated with 15.8% of the patients. The cervical level had a higher proportion of SCI (26.5%), followed by thoracic level (9.2%). The mean Elixhauser comorbidity score was 4.82 (SD, 2.17). Complete details are listed in Table 2.

2) Socioeconomic characteristics

Overall Central counties (24.8%) and Fringe counties (24.8%) are the predominant locations of the patients. Twenty-seven point seven percent of the patients fell in the 51st to 75th percentile of the zip codes' median household income. The most common insurance availed was Medicare (70.9%), followed by

Table 2. Demographics and discharge dispositions of the cohorts (weighted frequencies)

Variable	Overall (n = 5,385)	Cervical (n = 2,055)	Thoracic (n = 3,140)	Lumbar (n = 955)	Sacral (n = 120)
Age (yr)	71.63 ± 3.21	69.88 ± 13.58	72.20 ± 12.85	71.30 ± 13.4	69.54 ± 15.75
Sex					
Male	83.8	88.6	83.4	82.2	45.8
Female	16.2	11.4	16.6	17.8	54.2
Race					
White	4,170 (77.4)	1,520 (74)	2,455 (78.2)	740 (77.5)	100 (83.3)
African Americans	265 (4.9)	145 (7.3)	110 (3.5)	65 (6.8)	N/A
Hispanics	265 (7.9)	185 (9.3)	250 (8)	55 (5.8)	10 (8.3)
Asian/Pacific Islander	165 (3.1)	90 (4.4)	75 (2.4)	25 (2.6)	N/A
Native Americans	30 (0.6)	5 (0.2)	25 (0.8)	5 (0.5)	5 (4.2)
Others	110 (2)	40 (1.9)	65 (2.1)	30 (3.1)	N/A
Spinal cord injury	850 (15.8)	545 (26.5)	290 (9.2)	45 (4.7)	N/A
Elixhauser comorbidity score	4.82 ± 2.14	4.45 ± 2.05	5.13 ± 2.14	4.67 ± 2.28	6 ± 0
Insurance					
Medicare	3,820 (70.9)	1,375 (66.9)	2,265 (72.1)	675 (70.7)	70 (58.3)
Medicaid	225 (4.2)	130 (6.3)	80 (2.5)	35 (3.7)	10 (8.3)
Private	970 (18)	380 (18.5)	580 (18.5)	180 (18.8)	35 (29.2)
Self-pay	100 (1.9)	65 (3.2)	35 (1.1)	15 (1.6)	5 (4.2)
No charge	10 (0.2)	10 (0.5)	N/A	N/A	N/A
Others	250 (4.6)	90 (4.4)	175 (5.6)	50 (5.2)	N/A
Patient location					
"Central" counties of metro areas of ≥ 1 million population	1,335 (24.8)	470 (22.9)	785 (25)	270 (28.3)	50 (41.7)
"Fringe" counties of metro areas of ≥ 1 million population	1,335 (24.8)	520 (25.3)	785 (25)	240 (25.1)	30 (25)
Counties in metro areas of 250,000–999,999 population	1,185 (22)	515 (25.1)	635 (20.2)	175 (18.3)	15 (12.5)
Counties in metro areas of 50,000–249,999 population	495 (9.2)	205 (10)	275 (8.8)	80 (8.4)	10 (8.3)
Micropolitan counties	555 (10.3)	210 (10.2)	325 (10.4)	100 (10.5)	15 (12.5)
Not metropolitan or micropolitan counties	465 (8.6)	125 (6.1)	325 (10.4)	90 (9.4)	N/A
Discharge disposition					
Routine	1,040 (19.3)	445 (21.7)	585 (18.6)	165 (17.3)	10 (8.3)
Transfer to short-term hospital	240 (4.5)	110 (5.4)	160 (5.1)	20 (2.1)	N/A
Transfer other: includes skilled nursing facility, intermediate care facility, another type of facility	3,115 (57.8)	1,065 (51.8)	1,860 (59.2)	595 (62.3)	95 (79.2)
Home Health Care	640 (11.9)	235 (11.4)	370 (11.8)	125 (13.1)	15 (12.5)
Against Medical Advice	10 (0.2)	5 (0.2)	5 (0.2)	50 (5.2)	N/A
Died	335 (6.2)	190 (9.2)	160 (5.1)	N/A	N/A
Hospital charges (US dollar)	162,423.63 ± 16,7112	184,558.78 ± 183,818	163,523.38 ± 161,991	150,966.64 ± 136,839	142,685.26 ± 241,209
Median household income					
0–25th percentile	1,180 (21.9)	470 (22.9)	670 (21.3)	225 (23.6)	30 (25.0)
26th–50th percentile (median)	1,400 (26.0)	580 (28.2)	815 (26.0)	260 (27.2)	20 (16.7)
51st–75th percentile	1,490 (27.7)	580 (28.2)	870 (27.7)	220 (23.0)	30 (25.0)
76th–100th percentile	1,215 (22.6)	385 (18.7)	730 (23.2)	220 (23.0)	40 (33.3)

Values are presented as mean ± standard deviation or number (%).
NA, not available.

https://doi.org/10.14245/ns.2142712.356

private insurance (18%) (Table 2).

3) Surgical treatment and complications

A total of 2,365 patients (43.9%) underwent surgical treatment for the fractures. The most common surgery was fusion (71%), followed by corpectomy (29%). Fusion was the predominant surgery in all the groups. In the cervical level, 64.4% of the patients underwent 2 or more levels fusion. In thoracic fractures, 76.1% patients underwent 2 to 7 levels of fusion and 0.4% of the patients underwent more than 8 levels of the fusion. In lumbar fractures, 9.2% of the patients underwent 2 or more levels of fusion. The overall complication rate was 40.8% (Table 3). Respiratory complications, including pneumonia and respiratory insufficiency, were the predominant complications in the overall cohort (22.2%) as well cervical (27.7%), thoracic (21.5%), and lumbar (13%) levels (Fig. 2). Sacral fractures had lesser respiratory complications (13%). Cervical fracture patients (10.9%) required ventilatory support for more than 96 hours. The next common complication was acute kidney injury (AKI) (16.1%). Thoracic levels (18.3%) and lumbar levels (18.2%) had a higher proportion of AKI. Urinary tract infections (UTI) were found in 12.9% of the patients. Wound complications were found in 2.5% of the patients overall, with the lumbar level having the highest rate (5.2%). The cardiac complication rate was 1.7%, and the deep venous thrombosis rate was 2.3%. Sepsis was found in 5.1% of patients overall. The mean hospital stay was 11.44 days (SD, 12.57) overall. The in-hospital mortality rate was 5.7% overall, with the cervical level (7.9%) being higher than other levels. The mean hospital charges were $162,423.63 (SD, 167,112), with the cervical level having the highest charges ($184,558). Overall, the most common discharge disposition was to a skilled nursing facility or another type of facility for rehabilitation (57.8%), followed by discharge to home (19.3%).

Logistic regression analysis was used after adjusting for the Elixhauser comorbidities and SCI, predominantly affecting the complication rate (Table 4). The probability of the complications by the fracture level was computed through the odds ratio with the lumbar level as the reference. Based on the regression analysis, there was no significant difference (p = 0.45) in the complication rates based on the levels. The odds ratio of having a complication in the cervical level patients was 1.308 (95% confidence interval [CI], 0.829–2.064; p = 0.247), 1.141 (95% CI, 0.722–1.803;

Table 3. Surgical management, complications, length of stay, and mortality (weighted frequencies)

Variable	Overall	Cervical (n = 2,055)	Thoracic (n = 3,140)	Lumbar (n = 955)	Sacral (n = 120)
Surgery	2,365 (43.9)	1,010 (49.1)	1,420 (45.2)	385 (40.3)	20 (16.6)
Fusion	1,680/2,365 (71)	625/1,010 (61.9)	1,100/1,420 (77.5)	225/385 (58.4)	15/20 (75)
Corpectomy	685/2,365 (29)	385/1,010 (38.1)	320/1,420 (22.5)	160/385 (41.6)	5/20 (25)
No. of levels fused	NA	2/more = 64.4%	2 to 7 levels = 76.1% > 8 levels = 0.4%	2/more levels = 9.2%	NA
Any complication	40.8%	435/1,010 (43.1)	590/1,420 (41.5)	145/385 (37.7)	5/20 (25)
Wound complications	2.5%	15/1,010 (1.5)	40/1,420 (2.8)	20/385 (5.2)	5/20 (25)
Respiratory including pneumonia	22.2%	280/1,010 (27.7)	305/1,420 (21.5)	50/385 (13)	0%
Ventilation < 24 hr	2.7%	30/1,010 (3)	40/1,420 (2.8)	10/385 (2.6)	0%
Ventilation 24 hr–96 hr	5.9%	90/1,010 (8.9)	65/1,420 (4.6)	70/385 (7.8)	0%
Ventilation > 96 hr	8%	110/1,010 (10.9)	110/1,420 (7.7)	10/385 (2.6)	0%
Cardiac complications	1.7%	10/1,010 (1)	35/1,420 (2.5)	5/385 (1.3)	0%
Acute kidney injury	16.1%	125/885 (12.4)	260/1,420 (18.3)	70/385 (18.2)	0%
UTI	12.9%	105/1,010 (10.4)	195/1,420 (13.7)	45/385 (11.7)	5/20 (25)
Nerve root injuries	0.4%	5/1,010 (0.5)	5/1,420 (0.4)	0%	0%
DVT	2.3%	20/1,010 (2)	35/1,420 (2.5)	15/385 (3.9)	5/20 (25)
Sepsis	5.1%	30/1,010 (3)	75/1,345 (5.3)	45/385 (5.2)	5/20 (25)
In-hospital mortality	135/2,365 (5.7)	80/1,010 (7.9)	70/1,420 (4.9)	25/385 (6.5)	
Hospital stay (day)	11.44 ± 12.57	12.17 ± 14.9	11.13 ± 11.16	12.65 ± 17.2	41.75 ± 54 (median, 13)

Values are presented as number (%) or mean ± standard deviation unless otherwise indicated.
NA, not available; UTI, urinary tract infection; DVT, deep venous thrombosis.

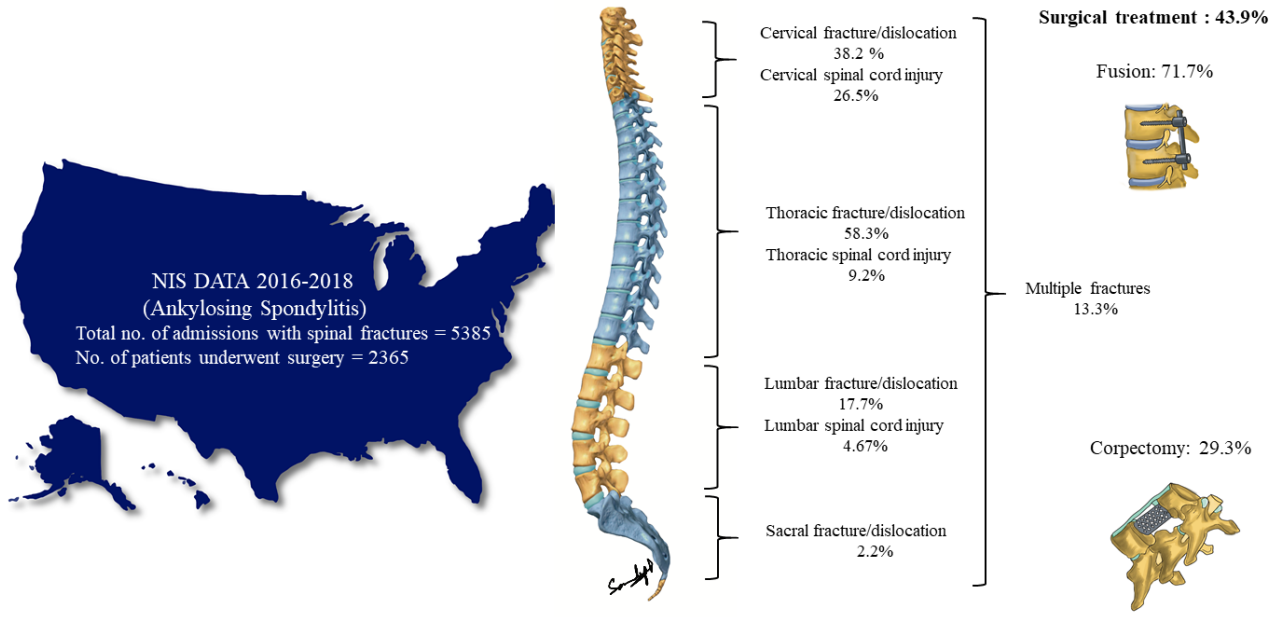

Fig. 2. Distribution of overall cohort, spinal cord injury, and surgical treatments. NIS, Nationwide Inpatient Sample.

Table 4. Logistic regression analysis of factors predicting complications and in-hospital mortality

Variable	Any complication			In-hospital mortality		
	OR	95% CI	p-value	OR	95% CI	p-value
Age	NA	NA	0.0518	NA	NA	0.0518
Elixhauser comorbidity score	NA	NA	<0.001	NA	NA	<0.001
Presence of spinal cord injury	2.164	1.722–2.72	<0.001	Excluded in the model		
Multiple levels	1.073	0.643–1.792	0.7866	2.527	0.913–6.998	0.0743
Cervical level	1.308	0.829–2.064	0.2472	1.761	0.714–4.341	0.2186
Thoracic level	1.141	0.722–1.803	0.5721	0.536	0.211–1.362	0.1894
Lumbar level	1.119	0.698–1.795	0.6395	1.26	0.513–3.098	0.6131

OR, odds ratio; CI, confidence interval; NA, not available.

p=0.5721) in the thoracic level, and 1.119 (95% CI, 0.698–1.795; p=0.6395) in the lumbar level; however, none of them were statistically significant. The presence of SCI increased the odds of having a complication by 2.164 times (95% CI, 1.722–2.72; p≤0.001), and a unit increase in Elixhauser comorbidity score increased the odds of having complications (p≤0.001). Age (p=0.296) and the presence of multiple fracture levels (odds ratio [OR], 1.073; 95% CI, 0.643–1.792; p=0.786) did not predict the complication rate. In-hospital mortality was predicted only by Elixhauser comorbidity score (p≤0.001) (Table 4).

DISCUSSION

Spinal fractures are a relatively rare complication of AS patients. Since AS is a relatively less common rheumatological disease, the literature describing the patterns of spinal fractures and complications of surgical management is mainly in the form of single-center studies and systematic reviews. Through the NIS database, we aim to review the treatment patterns and complications for traumatic fractures in AS patients at the national level. In our study, the majority of the patients underwent nonoperative management (56.1%). Our data is not granular enough to distinguish different types of nonoperative management due to the coding bias. Our study's most common fracture level was thoracic, followed by cervical level, although it differs with a few studies[9-13] (Table 5). In the operated patients, 40.8% had at least one complication, with respiratory (22.2%) being the most common complication. The presence of the complications did

 https://doi.org/10.14245/ns.2142712.356

Table 5. Literature review of ankylosing spondylitis with spinal fractures

Study	Total no. of patients	Average age (yr)	Patients with fractures	Total fracture incidents	Fracture location	Complications with rates (%)	Median length of stay (day)	Mortality rate (%)
Teunissen et al.[10] (2017)	2,089	69.3	172	189	C: 104 (60.8) T: 72 (42.1) L: 26 (15.2) S: 3 (1.8)	Pneumonia (50.6), respiratory failure (6.4), altered mental status (6.4), UTI (4.3), wound infection (2.1)	7 (3–15)	24.6
Longo et al.[11] (2015)	110	59.2	86	110	C: 110 (100.0) T: 0 L: 0 S: 0	Epidural (2.0) hematoma, pneumonia (5.0), infection (4.0), ARDS (2.0)	NA	21.0
Rustagi et al.[12] (2017)	-	63.4	-	-	C: 53.0 T: 41.9 L: 18.2 S: 1.5	Overall 84.0: (pneumonia, respiratory failure)	NA	32
Lukasiewicz et al.[9] (2016)	939	68.4	939	1,076	C: 53.0 T: 41.9 L: 18.2 S: 1.5	UTI (9.6), AKI (7), pneumonia (6.3)	NA	6.6
Sedney et al.[17] (2016)	38	74.0	38	38	T: 87.0 Multilevel: 13.0	Reoperation (13)	NA	13
Moussallem et al.[18] (2016)	41	75.56	17	17	C: 0 T: 30.0 L: 65.0 S: 2.5	Overall 67.5 (wound infection, DVT, PE, pneumonia)	NA	5.0
Altun et al.[13] (2016)	30	70.4	30	42	C: 60.0 T: 33.0 L: 3.0 S: 4.0	Pseudoarthrosis (3.3), wound infection (3.3), pneumonia (3)	NA	3.3
Robinson et al.[14] (2015)	17,297	65.7	990	1131	C: 53.9 T: 36.5 L: 25.0 S: 6	Pseudoarthrosis, wound infection	NA	17
Lu et al.[19] (2013)	28	54.2	25	25	C: 7.0 T: 52.0 L: 36.0 S: 5.0	Overall 66.7 (respiratory failure, empyema, osteomyelitis)	NA	0
Kouyoumdjian et al.[20] (2012)	19	60.84	19	19	C: 100.0 T: 0 L: 0 S: 0	Hematoma (5.3)	NA	26
Backhaus et al.[21] (2011)	119	67.0	119	129	C: 39.5 T: 42.6 L: 17.8 S: 0	Wound infection (14), Pseudoarthrosis requiring revision (15)	NA	NA
Caron et al.[5] (2010)	112	62.4	112	122	C: 55.0 T: 21.0 L: 8.0 S: 0 TL Jxn: 16.0	UTI (35), Wound infection (16), DVT (8)	NA	NA

(*Continued*)

Table 5. Literature review of ankylosing spondylitis with spinal fractures (continued)

Study	Total no. of patients	Average age (yr)	Patients with fractures	Total fracture incidents	Fracture location	Complications with rates (%)	Median length of stay (day)	Mortality rate (%)
Sapkas et al.[22] (2009)	20	55.4	20	20	C: 35.0 T: 45.0 L: 5.0 S: 0 TL Jxn: 15.0	Wound infection (5), Hardware loosening (10)	NA	NA
Kanter et al.[23] (2008)	13	60.4	13	13	C: 53.8 T: 46.2 L: 0 S: 0	Hardware failure (15), neurological decline (8)	NA	8
Thumbikat et al.[24] (2007)	18	56.2	18	18	C: 78.0 T: 14.0 L: 5.5 S: 5	Neurologic decline after surgery (17)	63–204	28

C, cervical; T, thoracic; L, lumbar; S, sacral; PE, pulmonary embolism; ARDS, acure respiratory distress syndrome; UTI, urinary tract infections; NA, not available; AKI, acute kidney injury; DVT, deep venous thrombosis.

not depend upon the fracture level rather dependent upon the Elixhauser comorbidities ($p \leq 0.001$) and the presence of the SCI (OR, 2.164; 95% CI, 1.722–2.72; $p \leq 0.001$). In our study, age was not a predictor of complication rate ($p = 0.296$).

1. Age

The mean age in our study was 71.63 years (SD, 13.21) with the range of 23 years to 90 years. Most of the studies reported a mean age of >65 years. Our study is in agreement with these studies.[9-12,14] As age increases, the severity of the disease increases and the chances of fall, predisposing to spinal fractures in these patients. Few single-center studies reported age as an independent predictor of mortality in AS patients with spinal fractures,[5] the inherent limitations in the NIS data precludes us from doing a survival analysis. Also, in our study, the in-hospital mortality rate was not affected by age ($p = 0.051$).

2. Sex

Our study showed a male predominance (83.8%), in line with the results of other studies. Interestingly in the sacral fractures, there was a female predominance (54.2%). Evidence shows the HLA-B27 allele (most important allele in AS) being less often positive in women, explaining the male predominance. Another interesting genetic study in AS patients showed 1,522 unique gene expressions in males and 291 genes in women compared to controls in the general population.[15] Hormones play an essential role in modulating the pain mechanisms, inflammation, and syndesmophytes development.[16] Rusman et al.[16] in their review, reported that although men have a higher radiological progression, the disease burden is equal.

3. Spinal Cord Injury

The rate of SCI was 15.8% in our study. SCI was associated with a higher chance of postoperative complications in our study. Westerveld et al.[4] reported an SCI incidence of 67.2% in 232 AS patients. Another study by Caron et al.[5] reported an incidence of 58%. In another older NIS database study, the incidence of SCI reported was 21.2%. There are significant discrepancies between the institutional cohorts and NIS data, reflecting the coding patterns and bias in the NIS sample. Also, the chance of having a delayed SCI in AS patients cannot be underestimated. Harboring an unstable fracture that was either missed in the initial evaluation or ignored by the patients as the injury is trivial can progress to a delayed SCI. Teunissen et al.[10] in their study, reported a delay in diagnosis of spinal fracture in 44.2% of the patients. The delay in diagnosis was associated with SCI in 4.1% of the cases. Similarly, Caron et al.[5] reported an incidence of 36.8% delayed diagnosis in their series. Hence it is recommended to evaluate for a spinal fracture in AS patients with persistent pain after minor fall/trauma even though the pain is not disabling.

4. Complication Rates

Our study showed that at least one complication was present in 40.8% of the patients who underwent surgical treatment. Respiratory complication was the most common (22.2%), followed by AKI (16.1%) and UTI (12.9%). Most of the studies showed

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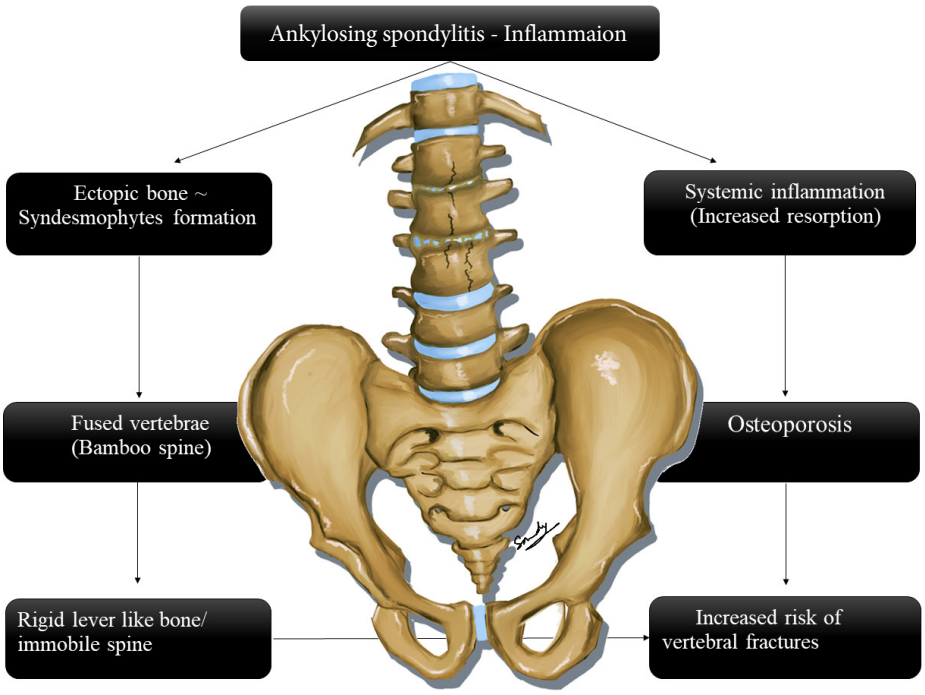

Fig. 3. Showing the distribution of the complications.

significant morbidity and complications in the AS patients irrespective of the treatment.[17-24] Based on these studies, the complications might be a manifestation of physiological endpoints of organ modeling in AS rather than the procedures per se (Fig. 3). The majority of people are near 70 years with a mean comorbidity score of 4.82, predisposing them to multiple postoperative complications. Our study showed ventilator dependency of more than 96 hours in 8% of the people, with cervical patients being higher (10.9%) than others. A Danish National registry reported 57.6% of AS patients have at least one or more comorbidities.[25] Interestingly they also reported that AS with pneumonia as a cause of admission did not increase the mortality rates. Although intriguing, our study cannot be compared with this registry as they differ in population sets. Westerveld et al. reported higher complications than the control population (85.7% vs. 48.7%) in the AS patients.[26] Lukasiewicz et al.[9] reported that fracture location did not correlate with the adverse events in agreement with our study. However, we included only inpatient complications, which can underreport the delayed complications if post-discharge was also considered.

5. Limitations

Our study has several limitations. The lack of SCI severity grading (pre-and postinjury), mechanism of the injury, readmission data due to complications, and long-term follow-up were a few, limiting us to discuss only the early complications in the postoperative period. Along with these, the preoperative comorbidities specific to AS which can influence the postoperative outcome were not available. We reduced this bias slightly by adjusting the Elixhauser comorbidities and SCI while calculating the odds of complication by the fracture level. Again, we do not have the information on the location of the fracture in the vertebrae (Denis 3 column-wise). Also, the NIS data comes with inherent selection and sampling bias along with interrater coding bias. The details regarding the nonoperative management in the data were also lacking.

CONCLUSION

AS patients with spinal fractures have higher postoperative complications. The most common fracture location was thoracic in our study, although it differs with few studies, with SCI occurring in 1/6th of the patients. Although with significant limitations, we intend to provide a bird's eye view of patterns, management, and complications in AS patients with spinal fractures.

CONFLICT OF INTEREST

The authors have nothing to disclose.

ACKNOWLEDGMENTS

This study was supported in part by U54 GM104940 from the National Institute of General Medical Sciences of the National Institutes of Health, which funds the Louisiana Clinical and Translational Science Center.

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