Comparing outcomes of early, late, and non-surgical management of intraspinal abscess

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A B S T R A C T

Intraspinal abscesses (ISAs) are rare lesions that are often neurologically devastating. Current treatment paradigms vary widely including early surgical decompression, drainage, and systemic antibiotics, delayed surgery, and sole medical management. The National Inpatient Sample (NIS) database was queried for cases of ISA from 2003 to 2012. Early and late surgery were defined as occurring before or after 48 h of admission. Outcome measures included mortality, incidence of major complications, length of stay (LOS), and inpatient costs. A total of 10,150 patients were included (6281 early surgery, 3167 delayed surgery, 702 medical management). Paralysis, the main comorbidity, was most associated with early surgery ($p < 0.0001$). In multivariate analysis, the rates of postoperative infection and paraplegia were highest with early surgery ($p < 0.0001$), but the incidence of sepsis was higher with delayed surgery ($p < 0.0001$). Early surgery was least associated with in-hospital mortality ($p = 0.0212$), sepsis ($p < 0.001$), and had the shortest LOS ($p < 0.001$). Charges were highest with delayed surgery, and least with medical management ($p < 0.001$). Medical management was associated with lower rates of complications ($p < 0.001$). This is the largest study of patients with ISAs ever performed. Our results suggest that patients with ISAs undergoing surgical management have better outcomes and lower costs when operated on within 48 h of admission, emphasizing the importance of accurate and early diagnosis of ISA.

1. Introduction

Despite a low prevalence in the population, intraspinal abscesses (ISAs) have the potential to neurologically devastate both healthy and sick patients [1]. ISAs primarily occur in the epidural space following either contiguous or hematological spread of infectious organisms [2–4]. The most common of these organisms is *Staphylococcus aureus*, which accounts for as many as two-thirds of infections, with other skin bacteria, gram negative bacteria, and fungi comprising the remainder [5]. These spinal epidural abscesses often damage the spinal cord by mechanical compression or vascular occlusion, both of which may result in cord infarction [4]. As the incidence of ISAs is rising due to the use of spinal instrumentation, intravenous drug abuse, and aging of the population, it is increasingly important to establish the utility of both surgical and non-surgical treatment strategies [4,6].

While the routine use of computed tomography and magnetic resonance imaging has increased the accuracy and rapidity of diagnosis, outcomes remain poor, with less than half of all patients achieving full recovery and a mortality rate as high as 16–19% [7,8]. Currently, the treatment of choice consists of urgent surgical decompression followed by four to six weeks of intravenous antibiotic therapy. Though some authors have demonstrated those not treated with early surgery to have worse outcomes, many studies have shown good outcomes with the use of conservative management [4,8–11].

Abbreviations: AHRQ, Agency for Healthcare Research & Quality; CHF, congestive heart failure; ISA, intraspinal abscesses; LOS, length of stay; MI, myocardial infarction; NIS, National Inpatient Sample; OR, Odds Ratio; PE, pulmonary embolism.

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Prospective trials investigating the treatment of ISAs have been lacking due to the rarity of this disease and the potential ethical difficulties of conducting a randomized study. Given the inconclusive evidence for the use of early surgery in treating these patients and the continued poor outcomes, we examined a national cohort of patients with ISAs to isolate the outcomes of these patients. We evaluated the complications, mortality, length of stay (LOS), and healthcare charges associated with surgical management within two days of hospitalization compared to later surgery and medical management.

2. Methods

2.1. Data source

We utilized the National Inpatient Sample (NIS) database from the Agency for Healthcare Quality and Research's Healthcare Cost and Utilization Project (Rockville, Maryland). The NIS contains discharge data for approximately 8 million hospital admissions across 1000 hospitals in 45 states annually from 1988 to 2013. It is the largest, all-payer inpatient database and records patient-related diagnoses and procedures using the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes. The NIS also includes charge information for all patients regardless of payer and provides a unique opportunity to study and quantify nationwide management trends and outcomes.

2.2. Study sample

Adults $\geqslant$18 years old diagnosed with an ISA (ICD-9-CM: 324.1) between 2003 and 2012 were included in the analysis ($n = 10{,}150$). Patients were categorized into three treatment groups: early surgery, delayed surgery, and other medical management. Patients in the early surgery group were defined as those who underwent reopening of laminectomy site (ICD-9-CM: 03.02), other exploration and decompression of spinal canal (03.09), excision or destruction of lesion of spinal cord or spinal meninges (03.4), or excision of intervertebral disc (80.51) within 48 h of admission. Patients in the delayed surgery cohort were those with one of the above interventions performed on or after 48 h of admission. Patients in the medical management cohort included those who only underwent injection or infusion of oxazolidinone class of antibiotic (e.g. linezolid) (ICD-9-CM: 00.14), injection of antibiotic (99.21), and/or injection of other anti-infective (99.22) and did not have one of the surgical codes at any point of their admission.

2.3. Covariates

The multivariate linear analyses accounted for both patient and hospital covariates. Patient variables included age at admission, gender, race, intravenous drug use status, diabetes mellitus status, presence of congestive heart failure (CHF), primary payer status, patient median income, and Charlson Comorbidity index (Table 1a). Hospital variables included number of hospital beds, hospital location and region, continuous hospital discharges, and hospital teaching status (Table 1b). Results of the multivariate regression analysis are displayed in Supplementary Tables 1–5.

2.4. Main outcome measures

The primary outcomes in this study were perioperative mortality, complications, and costs. Agency for Healthcare Research & Quality (AHRQ) comorbidities were analyzed, including a number of frequently considered conditions (Table 2). Complications included pulmonary embolism (PE), cardiac complications/acute myocardial infarction (MI), sepsis, severe sepsis, acute kidney failure, hemiplegia, quadriplegia, paraplegia, and monoplegia (Table 3). As secondary outcomes, we examined sepsis as a complication, LOS, and inpatient costs (Table 4). All outcome measures were compared between the three cohorts to evaluate correlations between the timing and types of management on patient outcome.

2.5. Statistical analysis

A generalized linear mixed effects model was constructed for each of the outcomes including mortality, binary complications, sepsis, LOS in days, and continuous patient charges. Appropriate link functions were selected for each outcome. Mortality and complications are analyzed using logistic regressions, and LOS and patient charges are analyzed by Poisson regression. Each model included continuous age at admission and hospital discharges. Cat-

Table 1a
Patient baseline descriptive statistics.

	All patients	Early surgery	Delayed surgery	Other management	Test statistic (*p*-value)
All records – No. (col%, row%)	10,150 (100.0, 100.0)	6281 (100.0, 61.88)	3167 (100.0, 31.20)	702 (100.0, 6.92)	
Age in years at admission					49.10 (<.0001)
Mean (SD)	57.1 (15.06)	55.9 (15.17)	58.9 (14.55)	59.3 (15.34)	
Median (IQR)	57.0 (48.0–67.0)	57.0 (47.0–66.0)	59.0 (50.0–69.0)	60.0 (49.0–70.0)	
n (Min – Max)	10,149.0 (0.0–103.0)	6280.0 (0.0–103.0)	3167.0 (0.0–95.0)	702.0 (0.0–95.0)	
Sex – No. (col%, row%)					2.98 (0.2256)
Male	6197 (61.08, 100.0)	3875 (61.72, 62.53)	1897 (59.92, 30.61)	425 (60.54, 6.86)	
Female	3949 (38.92, 100.0)	2403 (38.28, 60.85)	1269 (40.08, 32.13)	277 (39.46, 7.01)	
Race (uniform) – No. (col%, row%)					65.56 (<.0001)
White	6019 (74.17, 100.0)	3684 (76.93, 61.21)	1954 (70.64, 32.46)	381 (68.04, 6.33)	
Black	1066 (13.14, 100.0)	564 (11.78, 52.91)	407 (14.71, 38.18)	95 (16.96, 8.91)	
Hispanic	808 (9.96, 100.0)	401 (8.37, 49.63)	334 (12.08, 41.34)	73 (13.04, 9.03)	
Asian or Pacific Islander	135 (1.66, 100.0)	79 (1.65, 58.52)	48 (1.74, 35.56)	8 (1.43, 5.93)	
Native American	87 (1.07, 100.0)	61 (1.27, 70.11)	23 (0.83, 26.44)	3 (0.54, 3.45)	
Median household income quartile for patient's ZIP Code – No. (col%, row%)					8.55 (0.2008)
Low	2709 (27.52, 100.0)	1640 (26.82, 60.54)	893 (29.01, 32.96)	176 (27.04, 6.50)	
Low to Middle	2478 (25.18, 100.0)	1545 (25.27, 62.35)	773 (25.11, 31.19)	160 (24.58, 6.46)	
Middle to high	2368 (24.06, 100.0)	1502 (24.57, 63.43)	720 (23.39, 30.41)	146 (22.43, 6.17)	
High	2288 (23.24, 100.0)	1427 (23.34, 62.37)	692 (22.48, 30.24)	169 (25.96, 7.39)	
Primary expected payer (uniform) – No. (col%, row%)					159.00 (<.0001)
Medicare	4029 (39.80, 100.0)	2248 (35.90, 55.80)	1466 (46.41, 36.39)	315 (44.87, 7.82)	
Medicaid	1453 (14.35, 100.0)	863 (13.78, 59.39)	460 (14.56, 31.66)	130 (18.52, 8.95)	
Private insurance	3316 (32.76, 100.0)	2296 (36.67, 69.24)	853 (27.00, 25.72)	167 (23.79, 5.04)	
Self-pay	622 (6.15, 100.0)	395 (6.31, 63.50)	181 (5.73, 29.10)	46 (6.55, 7.40)	
No charge	88 (0.87, 100.0)	55 (0.88, 62.50)	24 (0.76, 27.27)	9 (1.28, 10.23)	
IV drug use – No. (col%, row%)					1.38 (0.5016)
No	9984 (98.36, 100.0)	6178 (98.36, 61.88)	3119 (98.48, 31.24)	687 (97.86, 6.88)	
Yes	166 (1.64, 100.0)	103 (1.64, 62.05)	48 (1.52, 28.92)	15 (2.14, 9.04)	
Calendar year – No. (col%, row%)					55.32 (<.0001)
2003	549 (5.41, 100.0)	356 (5.67, 64.85)	149 (4.70, 27.14)	44 (6.27, 8.01)	
2004	793 (7.81, 100.0)	514 (8.18, 64.82)	205 (6.47, 25.85)	74 (10.54, 9.33)	
2005	768 (7.57, 100.0)	506 (8.06, 65.89)	224 (7.07, 29.17)	38 (5.41, 4.95)	
2006	879 (8.66, 100.0)	526 (8.37, 59.84)	293 (9.25, 33.33)	60 (8.55, 6.83)	
2007	942 (9.28, 100.0)	568 (9.04, 60.30)	290 (9.16, 30.79)	84 (11.97, 8.92)	
2008	1073 (10.57, 100.0)	687 (10.94, 64.03)	309 (9.76, 28.80)	77 (10.97, 7.18)	
2009	1146 (11.29, 100.0)	711 (11.32, 62.04)	364 (11.49, 31.76)	71 (10.11, 6.20)	
2010	1306 (12.87, 100.0)	798 (12.70, 61.10)	413 (13.04, 31.62)	95 (13.53, 7.27)	
2011	1404 (13.83, 100.0)	825 (13.13, 58.76)	486 (15.35, 34.62)	93 (13.25, 6.62)	
2012	1290 (12.71, 100.0)	790 (12.58, 61.24)	434 (13.70, 33.64)	66 (9.40, 5.12)	