Postoperative intracranial neurosurgery infection rates in North America versus Europe: A systematic analysis

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Background: Postoperative wound infection (PWI) after intracranial neurosurgery remains a significant worldwide problem, resulting in substantial morbidity/mortality if not combatted quickly and energetically. Although the danger of PWI is universally recognized, the reported incidence of PWI after intracranial neurosurgery remains variable, ranging from 1% to 8% in published series. The impact of geography on this reported variability has not been previously investigated. To address this issue, published comprehensive intracranial neurosurgery series were reviewed, segregating findings geographically between North American and European series.

Methods: A comprehensive literature search was conducted using the Entrez gateway of the PubMed database. Studies conducted in North America and Europe reporting the incidence of PWI after intracranial neurosurgery were subjected to a thorough review. Data from studies meeting inclusion criteria (minimum of 500 cases with no systematic exclusion of procedures) were categorized by origin (North American/European) and design (retrospective/prospective). Recorded incidences were then compared using χ^2 analysis, and estimates of the relative risk of PWI were calculated.

Results: Seven studies (4 North American, 3 European) met all of the inclusion criteria, with a 2.6-fold greater PWI incidence reported in the European studies ($P < .001$). The relative risk of PWI for Europeans versus North Americans per operative case was 2.60.

Conclusion: PWI after intracranial neurosurgery was nearly 3 times more likely in European versus North American studies. These findings should be considered by clinicians when estimating the risks of intracranial neurosurgery, and highlight the need for future prospective studies to provide evidence-based explanations for these differences. (Am J Infect Control 2008;36:570-3.)

Wound infection after intracranial neurosurgery represents a clear and present danger necessitating immediate and energetic medical and/or surgical intervention.[1] Over the past 30 years, the advent of improved diagnostic imaging modalities, prolonged patient life span, and increased prevalence of solid organ transplantation have contributed to the increasing number of wound infections diagnosed after intracranial neurosurgery.[1] After initial inoculation (most commonly in the choroid plexus), approximately 100,000 bacterial organisms per gram of tissue are required to produce a postoperative wound infection (PWI), which commonly manifests as meningitis, brain abscess, subdural empyema, and/or epidural abscess.[1-5]

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Although the dangers of PWI are widely recognized, the rate of reported wound infection after intracranial neurosurgery varies widely, ranging from < 1% to > 8% in published series.[6-9] Recently, a North American study of > 1000 intracranial cases found a 0.8% incidence of PWI, far below the 5% to 7% reported in previous studies of comparable case size, all of which were of European origin.[6,10,11] To examine whether geography could play a role in the reported variation in the incidence of neurosurgical PWI, the present study involved a critical review of the literature investigating PWI after intracranial neurosurgery.

MATERIALS AND METHODS

Literature searches were conducted using the Entrez gateway of the PubMed database (http://www.ncbi.nlm.nih.gov/entrez/query.fcgi). The following keywords were queried singly and in combination: ''neurosurgery,'' ''infection,'' ''incidence,'' ''antibiotic,'' ''prophylaxis,'' ''craniotomy,'' ''intracranial,'' and ''series.'' There was no limitation on the database search with regard to language or year of publication. Articles reporting the incidence of PWI after intracranial neurosurgery were selected; editorials, reviews, and commentaries were excluded.

All articles were labeled as North American, European, or other, according to the geographic location

Table 1. European intracranial neurosurgery series included in the analysis

Author	Study Design	Number of Intracranial Cases	PWIs	PWI Incidence
Blomstedt et al, 1985[13]	Retrospective	1324	74	5.6%
Maurice-Williams et al, 1999[14]	Retrospective	652	12	1.8%
Korinek et al, 2006[10]	Prospective	6243	381	6.1%
Total		8219	467	5.7%

Table 2. North American intracranial neurosurgery series included in the analysis

Author	Study Design	Number of Intracranial Cases	PWIs	PWI Incidence
Tenney et al, 1985[15]	Retrospective	599	37	6.2%
Savitz et al, 1986[16]	Retrospective	1007	0	0.0%
NNIS report, 2003[17]	Retrospective	8059	195	2.4%
McClelland et al, 2007[11]	Retrospective	1587	14	0.8%
Total		11252	246	2.2%

of the reported series. To be consistent with the geographic origin of most clinical studies published on intracranial PWI, only articles originating in either Europe or North America were selected for evaluation. Series systematically excluding a neurosurgical procedure (eg, cerebrospinal fluid shunting), devoted to a singular aspect of operative neurosurgery (eg, neurosurgical oncology, deep brain stimulation series), composed of < 500 intracranial cases, failing to distinguish between cranial and spinal infections, or involving patient populations analyzed in larger series were excluded from further analysis. All of the studies meeting the inclusion criteria were then reviewed and categorized geographically. References from each of the articles were then checked to ensure that all available studies were reviewed. In studies differentiating cranial and spinal infections, only the cranial infections were included for the purpose of this analysis, even if the spinal infections were included in the final analysis of those original studies.

Data from individual studies in the North American and European groups were then combined for statistical analysis. The χ^2 test for nominal data was performed to evaluate the incidence of PWI after intracranial neurosurgery, with statistical significance assigned at a value of $P < .05$ when comparing combined cohort characteristics. An estimation of the relative risk of PWI was then computed for each cohort, with an accompanying 95% confidence interval.[12]

RESULTS

Study identification

A total of 34 published studies from North America and Europe were identified through the initial PubMed database searches and review of references. Of these, 7 studies met all of the inclusion criteria.[10,11,13-17] Three studies, 1 prospective[10] and 2 retrospective in design, were conducted in Europe (Table 1).[13,14] Four studies were conducted in North America, all of which were retrospective (Table 2).[11,15-17] The reasons for rejection of the 27 excluded studies[6-9,18-40] are given in Table 3.

Table 3. Reasons for rejection of 27 excluded studies

Reason for Rejection	Number (Reference)	Percentage
Fewer than 500 intracranial cases	14 (7,18-21,27-31,35-37,40)	52
No differentiation between cranial and spinal cases	9 (22-25,32-34,38,39)	33
Double publication of a cohort	3 (6,9,26)	11
Systematic exclusion of certain intracranial cases	1 (8)	4
Total	27	100

Incidence of postoperative wound infection

Data regarding the incidence of PWI in the included studies are presented in Tables 1 and 2. In the European studies meeting the inclusion criteria, a total of 8219 intracranial neurosurgery cases were complicated by 467 cases of PWI, for an incidence of 5.7%.[10,13,14] In the North American studies meeting the inclusion criteria, a total of 11,252 intracranial neurosurgery cases were complicated by 246 cases of PWI, for an incidence of 2.2%.[11,15-17] The 2.6-fold greater incidence of PWI after intracranial neurosurgery in European cases versus North American cases was statistically significant ($P < .001$). The relative risk of PWI for cases in the European studies compared with those in the North American studies was 2.60 (95% confidence interval, 2.23 to 3.02).

DISCUSSION

Since the advent of elective craniotomy, the reported rates of PWI after operative intracranial neurosurgery have been relatively variable. Most series based on patients operated on in North America have reported a PWI rate of no greater than 2% after operative neurosurgery.[7,8,18-24] However, in European series, the reported rate of PWI has been considerably higher, with some studies reporting estimated incidences as high as 8%.[6,9,25-40]

To explore this disparity between European and North American series, the present study involved a retrospective meta-analysis of previously published studies based in Europe or North America involving PWI after craniotomy. Of the more than 30 studies that were examined, only 7 met the inclusion criteria.[10,11,13-17] Most of the studies that were excluded either failed to differentiate cranial procedures from spinal procedures or consisted of fewer than 500 intracranial cases (Table 3). The findings from this meta-analysis are of concern, because the incidence of PWI after craniotomy in the North American studies (2.2%) was more than 2.5 times lower than that in the European studies (5.7%). This difference was found to be statistically significant ($P < .001$; χ^2 test). Furthermore, the findings indicate that a patient undergoing craniotomy in European studies was 2.6 times more likely to suffer a PWI than one undergoing craniotomy in North America.

The purpose of this study was to determine whether the wide range in PWI reported in the literature (1% to 8%) could be related to geographic origin. To best investigate this question, only the most comprehensive studies (covering > 500 patients) from Europe and North America (covering the majority of the neurosurgery infection literature) were included. Although the trend of higher neurosurgery infection rates in European series versus North American series was prominent in the excluded series as well, only those studies with significant patient populations without selective exclusion of neurosurgical procedures were included in the final analysis. Although this study examined geography as a potential factor in explaining the variability in PWI reported in the literature, unfortunately it was unable to provide evidence-based explanations for the differences between the European and North American studies.

Beyond this limitation, the study has several other limitations, stemming predominately from its retrospective nature and its inability to account for the uniformity of the original data collected among the analyzed studies. Moreover, the inability to standardize preoperative selection criteria, operative technique, antibiotic regimen, and postoperative care among the selected studies provides further limitations regarding the extent to which the study's conclusions can be applied to the neurosurgical population worldwide. Despite these limitations, the results shed some light on an important and relatively stable disparity in the incidence of PWI between North American and European centers. The origin of these differences is unclear, and definitive evidence-based answers will require large randomized prospective trials incorporating neurosurgical centers from both areas of the world.

In conclusion, this study found that the incidence of PWI after intracranial neurosurgery was nearly 3 times higher in European versus North American studies ($P < .001$), with a relative risk of PWI for Europeans versus North Americans of 2.60 per operative intracranial case. These findings should be considered by clinicians when estimating the risks of intracranial neurosurgery, and highlight the need for future prospective studies to provide evidence-based explanations for the differences.

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