Wrong-sided and wrong-level neurosurgery: a national survey

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Object. Perhaps the single greatest error that a surgeon hopes to avoid is operating at the wrong site. In this report, the authors describe the incidence and possible determinants of incorrect-site surgery (ICSS) among neurosurgeons.

Methods. The authors asked neurosurgeons to complete an anonymous survey. These surgeons were asked to report the number of craniotomies and lumbar and cervical discectomies performed during the previous year, as well as whether ICSS had occurred. They were also asked detailed questions regarding the potential determinants of ICSS.

Results. There was a 75% response rate and a 68% survey completion rate. Participating neurosurgeons performed 4695 lumbar and 2649 cervical discectomies, as well as 10,203 craniotomies. Based on this self-reporting, the incidence of wrong-level lumbar surgery was estimated to be 4.5 occurrences per 10,000 operations. The ICSSs per 10,000 cervical discectomies and craniotomies were 6.8 and 2.2, respectively. Neurosurgeons recognized fatigue, unusual time pressure, and emergent operations as factors contributing to ICSS. For spine surgery, in particular, unusual patient anatomy and a failure to verify the operative site by radiography were also commonly reported contributors.

Conclusions. Neurosurgical ICSSs do occur, but are rare events. Although there are significant limitations to the survey-based methodology, the data suggest that the prevention of such errors will require neurosurgeons to recognize risk factors and increase the use of intraoperative imaging. (DOI: 10.3171/SPI-07/11/467)

KEY WORDS • craniotomy • discectomy • incorrect-site surgery • wrong-sided surgery

Operations performed on the wrong side, body part, or person are among the most serious of surgical errors. Surgeons, who often bear primary responsibility for such events, have been reluctant to disclose their experiences in such circumstances, primarily due to fear of incrimination, criticism by fellow professionals, and shame among peers. Sensational articles by the media have further compounded the problem by being overtly critical of those directly involved in the error, while perhaps also engendering a sense of heightened concern about the delivery of health care.

In this study, we set out to survey neurosurgeons about their experiences with ICSS. Our primary goal was to estimate the incidence of this error during commonly performed spinal and cranial procedures. To gain an appreciation of the risk factors related to ICSS, we also asked neurosurgeons to identify the circumstances surrounding their experiences. Based on this information, we suggest a prevention strategy—the “ABCD Pause”—that we hope will further reduce the occurrence of unnecessary surgical mistakes.

Clinical Material and Methods

Survey Components

In our survey, we assured participants of confidentiality and nondisclosure of sensitive information. Neurosurgeons in active practice were informed that the aggregate data would be published. In addition, we offered neurosurgeons the opportunity not to answer our questions and yet acknowledge receipt of our survey by returning the questions incomplete. We sent the survey to each neurosurgeon three times by mail and once by fax.

In the first section of our survey, we requested information on the year that the responding neurosurgeon had start-
ed independent practice and completed his or her residency or fellowship training. We then requested information on the number of craniotomies and cervical and lumbar discectomies performed during the previous 365 days. To determine the number of ICSS events that occurred during the previous 365 days, we asked participants to count the number of these events separately for each craniotomy and lumbar and cervical discectomy. We defined wrong-sided craniotomy as having “cut skin on the wrong side” and wrong-level spine surgery as having “removed disc at the wrong level.”

Before administering the survey, we were concerned that the event rate for ICSS would be low. To address this possibility, we increased the event horizon by asking participants also to report the number of ICSS events that occurred during the previous 5 years, as well as during the entire period they had been in independent practice. We recognized that these estimates would not be as reliable or as valid as our 1-year estimates.

**Incorrect-Site Surgery Event Rate**

To estimate the rate of ICSSs, we first determined the total number of procedures performed during the previous year by all responding neurosurgeons. The rate was then calculated by dividing the total number of ICSS events (during the same 365 days) by the total number of procedures performed.

To obtain second-order estimates of ICSSs, we then calculated the total number of procedures performed during both the previous 5 years and the entire careers of participating neurosurgeons, taking into account the year each started practicing. These calculations required us to assume that practice patterns did not change over a neurosurgeon’s career, and that each had performed as many discectomies and craniotomies during the last 12 months as during the first year of practice. Five-year and career rates were then estimated by dividing the corresponding number of ICSS events by the total number of each type of procedure performed.

**Root-Cause Analysis**

To inquire further about circumstances surrounding ICSS events, we asked additional structured questions about the most recent time that a neurosurgeon was directly involved in such a mistake. We asked each to discuss craniotomy events separately from those involving the spine. We also requested each not to discuss events that had happened during his or her residency or fellowship years.

For each procedure, we asked in what year the error had occurred and who had made the error (resident, fellow, or respondent), as well as whether the case was an emergency or after-hours operation, whether fatigue or unusual time pressures had contributed to the mistake, whether intraoperative image guidance was performed, and whether appropriate preoperative imaging studies were available at the time of surgery. We also asked neurosurgeons to report when the error was disclosed to the patient, whether they believed the error was less likely to be committed today as compared with their first year of practice, and whether they believed the error was ultimately preventable. We also asked whether the case had gone, or was expected to go, to litigation.

In addition, for wrong-level spine surgeries, we asked which part of the spine was involved, whether intraoperative x-ray films or image guidance had been requested, and whether the patient had unusual physical characteristics (obese, conjoint nerve root, unusual anatomy, and so forth). For these cases, we asked neurosurgeons if they believed that intraoperative x-ray films or image guidance should be considered the standard of care. We also asked whether image guidance should be considered standard care in managing cranial surgeries.

In the final portion of the survey, we gave neurosurgeons an opportunity to comment on whether there had been a breach in standard protocol or a change in routine, and how they believed that the problem could have been avoided in their particular circumstances. These were open-ended questions.

**Validation of Cranial and Spinal Volume**

To validate the self-reported number of craniotomies and lumbar and cervical discectomy procedures performed per year by neurosurgeons, we requested the operative logs of eight neurosurgeons from our center. In addition, we used aggregate data on the numbers and types of procedures performed by 25 neurosurgeons at the University of Toronto.

**Statistical Methods**

Data from the surveys were entered into Excel spreadsheets (Microsoft Corp.) with double data entry. All analyses were performed with Stata version 6.0 (StataCorp LP). Statistical tests were two-tailed, with a 5% level of significance.

To compare the number of procedures performed by respondents with those performed by eight neurosurgeons from our center and 25 neurosurgeons at the University of Toronto, we used nonparametric tests with unequal variance.

**Results**

**Response Rate**

From the directory of the Canadian Neurosurgical Society and the Royal College of Physicians and Surgeons, we identified 194 neurosurgeons. Ten of these individuals were not eligible for our study because they were residents, fellows, or neurosurgeons not in active practice. After three mailings, one faxed communication, and a telephone reminder, 138 replies were received. From this group, 12 neurosurgeons returned the survey, declining to participate in our study; therefore, our survey had a 75% return rate and a 68% completion rate.

**Validation Data**

The average number of annual surgeries per participating neurosurgeon was as follows: lumbar 34.0, cervical 19.2, and cranial 73.9. When we compared these results with data from our center and the University of Toronto, the average number of each type of procedure performed was very similar to that reported in our survey (average number of surgeries per surgeon per year: lumbar 29.6, cervical 11.7, and cranial 74.8). There were no statistical differences

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in the survey results and data collected from our center and the University of Toronto.

Wrong-Sided Cranial Surgery

Two neurosurgeons acknowledged having operated on the wrong side during the year prior to completing the survey (Table 1). This result corresponded to an ICSS event rate of two occurrences per 10,000 operations. Second-order estimates for the previous 5 years and for the careers of these neurosurgeons were remarkably similar.

Among all responding neurosurgeons, 25% admitted to having cut skin on the wrong side of the head at one point during their careers. When we asked only those neurosurgeons who had been in practice for at least 5 years, 29% had made this mistake.

Wrong-Level Spinal Surgery

Among an estimated 4695 lumbar discectomies, disc material was removed from the wrong level on six occasions (rate 12.8/10,000 cases; Table 1). There were almost half as many cervical discectomies performed during the same period, and for this procedure the error rate was lower (rate 7.6/10,000 cases). For these spinal procedures, the 5-year and career estimates were similar to the 1-year estimates.

Thirty-two percent of responding neurosurgeons stated that, at some point during their careers, they had removed lumbar disc material from the wrong level. When we asked the same question about cervical disectomy, 16% of responding surgeons reported this mistake. Surgeons who had been in practice for at least 5 years were more likely to report having made this mistake (35% for lumbar and 19% for cervical disectomy).

Case Inquiry

When we asked questions about experiences with ICSSs, the neurosurgeons more often admitted that they themselves had made the error as opposed to another surgeon (resident or fellow). In cranial procedures, 27% of errors were made by a fellow and 73% by the surgeon. Similarly, in spinal cases, 29% of errors were made by the fellow, 2% by the resident, and 69% by the surgeon. Patients were not informed about the error in 15% of wrong-sided cranial surgeries and 19% of wrong-level spinal surgeries (Fig. 1). In 11% of wrong-sided and 10% of wrong-level surgeries, the case had gone, or was expected to go, to litigation.

Factors specifically related to wrong-sided cranial surgery were emergency operating conditions or surgery performed after hours (68% of cases), fatigue (19% of cases), and unusual time pressures to start or finish the procedure (42% of cases; Fig. 2). In 11% of wrong-sided cranial procedures, appropriate preoperative imaging studies were not in the operating theater at the time of surgery, and no intraoperative image guidance was performed. In 40% of the cases in which wrong-sided cranial surgery was performed, there was an acknowledged breach in standard protocol. In open-ended questions, neurosurgeons told us that the error was due in part to mental distraction, the Kernohan notch phenomenon (false localization of the hematoma on the side of the dilated pupil), prone positioning, an unusual operating theater setup, an intraoperative change in head positioning, incorrect placement of an image on the viewing box, illegible skin marking, and failure to double-check the incision. Interestingly, in two independent incidents, patients had been placed feet first in the computed tomography scanner (trauma protocol at many centers), and their imaging studies were labeled incorrectly.

Factors frequently reported to occur during wrong-level spinal surgery included a failure to use intraoperative x-ray films or image guidance to confirm the spinal level (30% of cases) and unusual patient anatomy or physical characteristics (38% of cases; Fig. 3). In contrast to the case of wrong-sided cranial surgery, emergency operating conditions or surgery performed after hours (0% of cases), fatigue (4% of cases), and unusual time pressures to start or finish the procedure (6% of cases) were minor contributing factors. In 9% of wrong-level spinal surgeries, appropriate imaging studies were not in the operating theater during the time of surgery. In 21% of wrong-sided spinal surgery cases, there was an acknowledged breach in standard protocol. Other responses provided in the open-ended questioning section were almost all related to intraoperative imaging. Wrong-level spinal surgery occurred because of the unavailability of intraoperative x-ray films (for example, the x-ray machine was not working), poor-quality imaging studies (poor technique or unusual patient positioning), misinterpretation of images (due to congenital spinal anomalies or inexperience in interpreting intraoperative images), and failure to repeat x-ray filming when either the localizing needle moved or retractors slipped. To avoid wrong-level spinal surgery, neurosurgeons suggested the following: obtaining preoperative localizing x-ray films in addition to intraoperative films; notching the annulus once the localizing needle was inserted; having a consistent system of counting vertebral segments, particularly when faced with unusual spinal anatomy; and verification of the appropriate level by an independent person.

When we inquired about the frequency of using intraoperative x-ray films, every surgeon who had operated on the cervical spine stated that they had confirmed the cervical level in all cases. The frequency was lower for lumbar disc surgery, with only 68% of surgeons always using intraoperative imaging.
Almost all neurosurgeons who had reported ICSS events told us that they believed the error was preventable (100% of cranial cases and 91% of spinal cases). Of those persons surveyed, 64% suggested that intraoperative x-ray films should be considered the standard of care for spinal disc procedures. In contrast, only 4% of responders considered image guidance to be necessary for cranial operations.

**Discussion**

One in four neurosurgeons has operated on the wrong side of the head. In a 12-month period, this error occurred at least twice. Our data suggest that ICSS occurs even more frequently during spinal procedures. In a root-cause analysis, we identified several factors that contributed to these errors as follows: fatigue, emergency operating conditions, unusual anatomy, radiological errors, distraction, and unusual time pressures. Virtually all neurosurgeons thought the error was preventable.

**Frequency of ICSSs**

Accurate information on the incidence of wrong-sided cranial surgery does not exist; however, some information about ICSS is known among orthopedic and hand surgeons. For example, when the American Society for Surgery of the Hand polled its members about their experiences with ICSS, they estimated the incidence to be one occurrence per 27,686 surgeries. In North Dakota four surgeons from the Orthopedic Institute of Fargo undertook a more formal retrospective review in which they found an incidence of one in 15,987 operations. The incidence in Fargo may have been influenced by the implementation of a marking protocol during the study period. It is interesting to note that, when the American Society for Surgery of the Hand looked at the rate of ICSS as a function of annual caseload, they found that surgeons who performed more operations per year were more likely to make the mistake. They also found a trend toward more occurrences among more experienced surgeons, a finding similar to our own. These observations suggest that ICSS may be an adverse event that does not necessarily follow a learning curve; that is, more experienced senior surgeons are not protected by learning from their mistakes. This finding is important because it suggests that an individual surgeon or even a group of surgeons may not be able to amass enough experience with this problem to suggest a systematic, empirically based prevention strategy. Although, in the present survey, surgeon mistakes were separated from resident/fellow errors, another explanation for the higher incidence among experienced surgeons is that they often have more assistance in the operating room and become more reliant on ancillary help, such as that provided by residents and fellows in draping and exposing the surgical site. This factor would potentially increase the risk of ICSS.

**Causes of ICSS**

The JCAHO, a recognized leader in evaluating and accrediting healthcare organizations, asked their nearly
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17,000 participating healthcare organizations to report sentinel events, including ICSS. In 1998, the JCAHO issued its first report in which they analyzed 15 cases related to surgery at the wrong site. It suggested that ICSS was more likely to occur when more than one surgeon was operating on a patient, when multiple procedures were being performed at the same time. It also indicated that, when care was transferred between surgeons, similar mistakes were possible. Unusual patient characteristics and time pressures to begin or set up a procedure were also considered risk factors for ICSS. The JCAHO was able to support these findings by extending their observations to include 150 cases by 2001. In a subsequent report, the JCAHO found that operations performed during emergency conditions also were more likely to occur at the wrong site.

In the present study, frequently reported factors among cases of wrong-sided cranial surgery included emergency operating conditions, fatigue, and time pressures to start or finish a procedure. Other risk factors included mental distraction, false-localizing clinical signs, prone positioning, unusual operating theater setup, intraoperative change in head positioning, incorrect placement of images on the viewing box, illegible skin markings, and failure to double-check the incision. Factors frequently reported to occur during cases of wrong-level spinal surgeries included misinterpretation of intraoperative imaging, no intraoperative imaging, and unusual anatomy or physical characteristics.

Limitations of This Study

In the present study, we estimated the occurrence rate of wrong-sided cranial and wrong-level spinal surgery on a national scale. Note, however, that our results may not be applicable to other nations, because medical mistakes are not only the result of human and nonhuman error, but also are influenced by the availability of resources, the professional culture, public perception, and the medicolegal environment.

There are several further limitations of this study. Because we constructed each denominator by aggregating self-reported estimates, it is possible that some of this information was inaccurate. Our primary estimates were based on events of the immediately preceding year so that neurosurgeons would be more likely to recall information. We also distributed the survey in January, because we specifically wanted participants to reflect on the entire calendar year to facilitate information retrieval; surgeons are often able to determine their operative case volumes based on computerized calendar-year logs. Most importantly, when we compared the mean number of cranial and spinal surgeries performed by our survey participants with the known counts for the 33 neurosurgeons at two treatment centers, we found no significant difference.

It is also possible that cases of incorrect-level spinal surgery were never recognized—a more likely occurrence if a surgeon does not routinely use intraoperative imaging to verify the surgical site. Every surgeon who had operated on the cervical spine stated that they had confirmed the cervical level in all cases, whereas only 68% of responders reported verifying the location of lumbar disc surgery. Therefore, it is possible that a patient undergoing lumbar discectomy could have been discharged without having had the appropriate surgery. In many of these types of cases (failed-back syndrome), contemporary management practices dictate repeated imaging. Given the natural history of lumbar disc disease, however, it is possible that, in some patients, symptoms might have improved and the error was never identified.

Another limitation of the current study is the assumption that the first-year surgical caseload is similar to the most recent volumes; such an assumption is not necessarily true given that new surgeons gradually ramp up the case volume while developing their practice. This factor may not be as relevant in the Canadian healthcare system, in which new recruits are frequently inundated with referrals because of long waiting times. Another potential limitation of our study is the unwillingness of neurosurgeons to disclose their experiences with ICSS because of the sensitivity of the questions being asked. Remarkably, the estimated 1-year incidence rates for all three ICSS events were very similar to the 5-year and career rates, with only slight attenuation. Because operating at the wrong site is an almost unforgettable event, we believe that neurosurgeons would have no difficulty in remembering such a mistake, but perhaps some surgeons intentionally did not report the occurrence. Therefore, we believe our results should be interpreted as lower-bound estimates of the true rate of ICSS.
Prevention of ICSS

On the day of surgery, application of the surgical plan begins. The surgeon should visit the patient preoperatively, not only to “sign the site,” but also to verify the accuracy of documents and imaging. New evidence indicates that marking the site of surgery before the patient enters the operating room reduces the chances of an ICSS.12 Although this practice is commonly performed among orthopedic surgeons, it has been less widely adopted among other surgical specialties. In cranial cases, shaving of the scalp is usually performed after the induction of anesthesia; in such cases, signing the site may not be possible. For spinal surgery, no external landmarks reliably identify the surgical level; thus, signing the site is not applicable. Nonetheless, the surgeon should confirm the side and level of the radiculopathy while the patient is in the preoperative holding area, and these factors should be noted on the preoperative x-ray films or in the operating room if the imaging is computer based. Ideally, the side, the level, and an arrow pointing to the involved disc space should be written on the preoperative imaging study. For spinal cases, preoperative plain x-ray films and advanced imaging studies should always be present at surgery, and intraoperative confirmation of the level should always be obtained.

Before the first incision, some type of pause or time-out procedure can provide further security. We propose the ABCD Pause, a modified version of the time-out policy, in which the operating surgeon pauses before incising the skin and states aloud the site where the incision is to be made. After this step, other members of the operating team verify the patient and surgical site by reviewing the booking of the case according to the operative schedules, the consent form is recited, and the surgeon reviews the diagnostic images. Finally, the operating surgeon should drape the surgical site, a step often performed by residents or fellows in academic institutions. This step may be particularly important in peripheral nerve surgery. Additional checkpoints could further reduce the incidence of ICSS but must take into consideration losses in time and efficiency and the difficulties in implementing new policies.

Conclusions

All surgeons must acknowledge that ICSS occurs and yet is completely preventable. A successful prevention strategy requires intervention at multiple stages from diagnosis to incision. Although ICSS may never be completely eliminated, its incidence can be reduced.

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References


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