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Wrong-site craniotomy: analysis of 35 cases and systems for prevention

Clinical article

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Object. The purpose of this case review was to identify and analyze existing wrong-site craniotomy (WSC) cases to determine the factors that contributed to the errors and to suggest preventative strategies for WSC. Wrong-site surgery (WSS) is a devastating surgical error that has gained increased public attention in recent years due to some high-profile cases. Despite the implementation of preventative methods such as preoperative checklists and surgical time-outs, WSS still occurs to this day. The clinical consequences of WSC are distinct compared with other types of WSS due to the unique function of the brain.

Methods. The authors searched medical, legal, and media databases and contacted state medical licensing boards to identify and gather information about WSC cases. The cases were reviewed and analyzed for factors that contributed to the errors.

Results. Four major categories of contributing factors were found: 1) communication breakdown; 2) inadequate preoperative checks; 3) technical factors and imaging; and 4) human error. The WSC cases are used to illustrate how these types of factors can precipitate the surgical error. Clinical outcomes and disciplinary actions are summarized. Obtaining information about the cases discovered was very challenging, in part because WSS reporting is inadequate.

Conclusions. This case review demonstrates that a broad range of events and factors can cause human errors to breach patient safeguards and lead to a WSC; however, in essentially all cases the WSCs were preventable with strict adherence to comprehensive and thorough protocols. *(DOI: 10.3171/2009.10.JNS091282)*

Key Words • **wrong-site surgery** • **craniotomy** • **error**

Performing WSS may be the most regrettable and egregious error a surgeon can commit. Wrong-site surgery can lead to devastating outcomes. In 1995, a WSS case sparked massive media and public attention when an orthopedic surgeon amputated the incorrect foot of a 51-year-old man. The consequences of the mistake extended beyond the patient's unimaginable suffering; the surgeon and the hospital were sued in a civil lawsuit and the patient was awarded $1.2 million.[20] A WSS can be overwhelmingly harmful to the patient and both emotionally and financially costly to health care providers. Hospital officials attributed the error to a "breakdown in communication."[50] When asked how the surgeon should be disciplined, the patient responded that he did not hold the surgeon alone responsible for what had happened: "There's a problem there somewhere that needs to be corrected, and I don't know what it is and I don't know how to go about it."[20]

Increasing awareness and reporting of WSS cases has led to the development of guidelines and systems for prevention. However, despite nearly universal implementation of surgical time-outs and other safe surgery practices, WSS cases continue to occur. Eradication of these lamentable errors will require careful examination of the factors contributing to WSSs and the development of practical, implementable, and rigorous approaches for avoidance and prevention.

Neurosurgery is the third most vulnerable specialty to WSS behind orthopedic and general surgery.[31] These specialties possess inherent risk factors for WSS including multiple surgeons involved in cases and time pressures causing verification steps to be rushed or skipped. While the impact, both emotional and physical, of any WSS, is incalculable to the victim, this may be particularly true when

Abbreviations used in this paper: JCAHO = Joint Commission on Accreditation of Healthcare Organizations; OR = operating room; WSC = wrong-site craniotomy; WSS = wrong-site surgery.

the surgery has been performed in or on the brain. Given that many neurological functions require bilateral input, errant resection or damage to a healthy side of the brain increases the likelihood of poorer neurological outcomes. Consider an unnecessary resection of temporal lobe tissue for focal epilepsy due to a WSC followed by resection of the epilepsy focus from the correct side: ablation of one side alone may have minimal consequences on cognitive functions; however, damaging both temporal lobes can cause anterograde amnesia. A WSC also introduces delays in treatment that may increase the risks of infection and complications intraoperatively, further exacerbating the impact on clinical outcomes. Thus, WSC deserves special attention as a unique subset of WSS.

The prevalence of WSCs remains elusive because several factors complicate estimations. First, WSCs are likely to be underreported. The punishments prescribed for these misadventures, not to mention the ostracism and shame for something so seemingly simple to avoid, limit the accumulation of hard data. Although some cases have been reported in the media, these are likely to represent a fraction of the true number of occurrences. Second, even when events are reported, obtaining data from licensing boards and health departments is a daunting task. The majority of state licensing boards are incapable of conveniently recalling available data. Despite these challenges, attempts have been made to quantify the prevalence of WSC.

An indirect estimate of the number of potential wrong-side craniotomy cases in the US can be derived from US Census Bureau statistics,[76] the Congress of Neurological Surgeons,[17] and a Canadian survey study.[30] The study surveyed Canadian neurosurgeons asking for information and personal recollections regarding each individual physician's experience with wrong-sided brain surgery. Using estimates of the number of craniotomies performed per year in the US[17,76] and an estimated incidence of wrong-sided craniotomies of about 2.2 per 10,000 craniotomies,[30] of approximately 145,000 craniotomies performed in 2002, 32 were performed on the wrong side.

In this multicase review, we attempted to uncover as many occurrences of WSC as possible, acquire all the information available pertaining to each case to analyze the factors contributing to WSC, explore the range of clinical and legal outcomes, and suggest measures that may help to reduce or eliminate future cases of WSC. The high profile of this error combined with the fact that the 2 senior authors (F.L.C. and M.B.) had personal experience with WSC in the past stimulated us to review these cases by accessing all available sources including the legal literature.

Methods

Information regarding WSC cases was acquired using 3 different methods; 1) Medline, LexisNexis, and WestLaw database searches; 2) a media search; and 3) a brief questionnaire emailed to all 50 state medical licensing boards.

We searched Medline from 1966 to July 1, 2009, and LexisNexis and Westlaw from all available dates to July 1, 2009, using the following search terms: "wrong site" or "wrong side" and "craniotomy" or "brain surgery." A media search was conducted with Google News from all available dates to July 1, 2009, using the same search terms. Once cases were identified, disciplinary actions from state medical licensing boards and court records from civil lawsuits were obtained when possible using medical licensing board license searches and civil court records requisitions. In some cases, we directly contacted attorneys involved in the litigation and acquired additional information through personal communications.

We surveyed 50 state medical licensing boards by using a brief survey instrument administered by email to addresses obtained from the board's websites. The instrument poses the following questions: 1) How many cases of wrong-sided brain surgery do you have in your files *from your state only* (not cases that have been reciprocally reported about one of your licensees from another state or jurisdiction, based on mandatory reporting requirements)? 2) Understanding that each case is fact-specific, what is the minimum mandatory punishment for any of the above violations? What is the maximum? Is there a fairly standard punishment that is handed out in the majority of these cases?

The factors contributing to the cases reviewed were based on either objective findings of regulatory board and disciplinary actions or subjective determinations by the authors. The factors were grouped into 4 general causes based on the authors' critical analyses. The precipitating factors for each case are listed in the summary table (Table 1). For objective conclusions on precipitating factors, the factors are listed in the order in which they were reported in the official documents. For subjective determinations of factors contributing to the errors, the factors are listed in the table in no particular order. The table distinguishes between objective and subjective conclusions using italicization.

Results

Wrong-Sided Craniotomy Cases

The Medline, LexisNexis, Westlaw, and media searches yielded 34 cases of WSC. One additional case was discovered through correspondence with a state licensing board. A report from England's National Health Service mentioned 14 WSC cases, and a second report from the National Patient Safety Agency mentioned 15; however, no details were provided about specific cases and these were not included in the cases reviewed.[22,44] All 35 WSC cases are presented in a summary table (Table 1). Most of the information was based on media reports and state board disciplinary hearings. Only one case was reported in the peer-reviewed medical literature.[9] In some instances, we were able to retrieve legal documents from civil lawsuits or state administrative disciplinary actions. However, many civil lawsuits could not be retrieved because legal search engines (LexisNexis and Westlaw) do not include cases that are settled out of court or trial verdicts that are not appealed. The majority of the civil lawsuits mentioned in the media reports must have been settled out of court or at trial and, therefore, were not obtainable for inclusion in this case review. In addition, for some cases, legal information is protected by confidentiality agreements. At present, it is extraordinarily difficult to obtain information on WSC cases.

TABLE 1: Summary of WSC cases*

Case No. & Year†	Clinical Scenario & Operative Facts	Factors Contributing to the Error‡	Disciplinary Outcome (regulatory board, hospital action, civil litigation)
1. 1973[1,48,67]	Brain tumor. Surgeon operated on wrong side during resection. Error realized in OR, & tumor was resected from the correct side.	1) Surgeon alleged that a late conclusion about side controlling speech caused the error. *2)* Failure to mark incision site *(inadequate preop checks).*	No board or hospital action or civil lawsuit.
2. 1974[1,48,67]	Carotid artery aneurysm. Surgeon operated on the wrong side. Error realized 4 hrs into the op. The patient recovered but lost sense of smell because of the WSC.	Surgeon alleged error due to: 1) Working w/ unfamiliar nurse *(communication breakdown).* 2) Equipment absent at start of case *(technical factors).* Hospital determined: 3) Failure to mark incision site *(inadequate preop checks).*	A local neurosurgical society review found the surgeon was not incompetent but careless & negligent. 2 hospitals imposed restrictions on the surgeon such as orders to mark incision sites preop. Patient filed civil lawsuit (settled out of court). City's anesthetists refused to provide surgeon w/ op services. Surgeon unsuccessfully sued anesthetists & hospitals.
3. 1980[24]	Female w/ rt frontal lobe intracerebral hematoma following MVA. Op originally for lt temporal epidural hematoma. Postop CT revealed rt frontal lobe intracerebral hematoma. The CT scan was first ever acquired at the hospital w/ a new GE scanner that reversed the laterality convention. The surgeon was unaware of the change & operated on incorrect side. Error realized on postop CT scan. Surgeon obtained consent & operated on correct side.	The hospital purchased a new CT scanner that reversed the laterality convention *(technical factors).* The radiology department did not notify staff at the hospital *(communication breakdown).*	The state board disciplinary ruling: 1) WSC caused no harm to patient because lt frontal tissue was already infarcted & the patient's problems postdischarge were unrelated to brain damage caused by WSC. 2) Surgeon's error was regrettable but understandable. Error not due to negligence but to a rapid changeover in state-of-the-art medical technology. The surgeon was not held liable.
4. 1984[64]	30-year-old male w/ a rt temporal lobe meningioma. Surgeon failed to check imaging prior to op & operated on wrong side. 100 g of healthy temporal lobe was resected. Error realized by patient's wife who noticed bandages & drains on the wrong side. Surgeon resected the tumor the next day. The patient alleged ongoing depression, mood swings, & decreased libido due to the WSC. Neuropsychological assessments were inconclusive.	1) Failure to confirm site of lesion w/ imaging *(inadequate preop checks).*	The state board issued a letter of concern. Surgeon has no disciplinary record. Patient filed a civil lawsuit & settled out of court w/ the surgeon for $150,000.
5. 1989[39]	48-year-old male w/ 2 rt-sided brain tumors. Surgeon performed the craniotomy on the wrong side.	Surgeon said incision "inadvertently made on the wrong side of the head. This unfortunate occurrence was an oversight on my part."	Patient filed a civil lawsuit.
6. 1992[61,a]	54-year-old male w/ arachnoid cyst. Surgeon prepped patient for craniotomy on wrong side because of misreading lt/rt imaging designation. Error realized before entering the dura & op was completed on correct side.	The surgeon misread lt/rt imaging designation.	The state board disciplinary ruling: 1) Surgeon was reprimanded. 2) Assessment & CME on risk management. 3) Ordered to pay for assessment & CME. Patient filed a civil lawsuit & was awarded $200,000.

(continued)

TABLE 1: Summary of WSC cases* *(continued)*

Case No. & Year†	Clinical Scenario & Operative Facts	Factors Contributing to the Error‡	Disciplinary Outcome (regulatory board, hospital action, civil litigation)
7. 1995[3,4,45,62,63,68]	59-year-old female w/ lt temporal glioma. Patient was referred to the surgeon by a colleague who was away. Attending surgeon did not call the referring surgeon despite instructions to do so. Surgeon did not review medical record or images prior to op. Surgeon assumed patient was a different patient w/ rt-sided tumor. Surgeon operated on wrong side, partially resected rt temporal lobe & biopsied tissue. Error realized postop & patient had surgery at another hospital. Family members reported patient "had been … unable to read or concentrate" following WSC although a state investigation found that effect of the WSC was unclear.	The state health department investigation: 1) Poor communication between doctors. 2) Inadequate preop exam. 3) Failure to review medical records prior to op. 4) Failure to verify that imaging in OR belonged to the patient *(communication breakdown & inadequate preop checks)*.	The state board disciplinary ruling: 1) Surgeon liable for WSS & gross negligence. 2) Surgeon fined $10,000 & ordered to be monitored. The Health Department fined the hospital $12,000 & requested a plan of correction. The hospital immediately suspended the surgeon from patient care & dismissed the surgeon w/in 1 yr.
8. 1995[12,19,55,73,74]	39-year-old male w/ rt intracerebral hematoma. Patient required emergency brain op late at night. Surgeon viewed the CT scan of a rt hematoma. However, patient had a lt black eye; surgeon assumed clot was on lt side. Error realized 1 hour into the op before entering parenchyma. Surgery completed on correct side. Lt black eye was from fall sustained earlier. WSC was not expected to affect the patient's recovery.	The surgeon recognized responsibility for the error.	The State Board disciplinary ruling: 1) Surgeon was reprimanded. 2) Surgeon was fined $1000. Surgeon's op privileges suspended pending an investigation & reinstated w/in wks.
9. 1996[36]	18-year-old male w/ "bleeding" following MVA. Emergency CT scan was mislabeled; lt/rt laterality was incorrectly reversed. Surgeons operated on the incorrect side. Court documents stated that the op caused the patient to suffer long-term problems including "great mental, physical, & nervous pain & suffering."	Error due to mislabeled CT scan that incorrectly reversed the laterality convention *(technical factors)*. The patient: "I wouldn't blame it on the doctors, it was basically a technician's fault."	Patient filed a civil lawsuit & awarded $500,000.
10. 1997[2,57]	66-year-old female w/ rt temporoparietal tumor. Before op for biopsy, a nurse prepped & shaved incorrect side. Incision was made & a bur hole was drilled into wrong side. Mistake realized before cutting dura, & op completed on correct side.	The surgeon alleged error due to: 1) Nurse shaving, cleaning & draping cloth on wrong side *(communication breakdown)*. 2) Failure to review the medical record prior to op *(inadequate preop checks)*.	The state board found the surgeon liable for: 1) Breaching the standard of practice. 2) Performing a WSS. The state board disciplinary ruling: 1) Letter of concern issued. 2) Fined $5000 for the WSS. 3) Fined $982.24 for administrative costs. 4) 5 hrs of CME on risk management.
11. 2000[15,25,78]	Patient's diagnosis unrelated & another patient had 4.5-cm brain cyst. Radiologist issued imaging report w/ wrong patient's name & surgeon failed to notice that CT scan was of another patient. Patient's attorney alleged patient had strokelike syndrome including dysphasia postop. Other patient who was not operated on returned to the emergency room a few weeks later in a coma & later died.	1) Imaging report issued w/ wrong patient's name *(technical factors)*. 2) Failure to verify identity of CT scan in OR *(inadequate preop checks)*.	Patient filed civil lawsuit & was awarded $1.775 million due to permanent neurological damage. Surgeon paid $810,000 (45%), hospital payed $355,000 (20%), & radiologist settled out of court for an undisclosed amount. Other patient's family also filed civil lawsuit.
12. 2001[34,40,43]	41-year-old male w/ rt epidural hematoma. Attending physician prepped & shaved wrong side based on CT scan hung backwards. Surgeon operated on the wrong side, discovered error, completed op on correct side. Patient was reported to be stable postop.	1) CT scan hung backward. 2) Surgeon briefly initiated op prep due to emergency & falsely assumed that prepped side was the correct side *(communication breakdown & inadequate preop checks)*.	The state health department fined the hospital $14,000. Surgeon & radiologist have no disciplinary records. Hospital suspended 6 doctors & a nurse. Patient filed civil lawsuit against the doctors & hospital.

(continued)

TABLE 1: Summary of WSC cases* *(continued)*

Case No. & Year†	Clinical Scenario & Operative Facts	Factors Contributing to the Error‡	Disciplinary Outcome (regulatory board, hospital action, civil litigation)
13. 2001[37,b]	36-year-old male w/ rt-sided aneurysm. Surgeon prepped & shaved wrong side. Error realized when no aneurysm was found. Aneurysm clipped on correct side immediately. The patient reported seizures, memory problems, personality changes & an inability to hold a job. Postdischarge PET scans, MRIs, & neuropsychological testing showed brain injury on WSC side.	Surgeon alleged that unfamiliar OR setup caused the error *(technical factors)*.	Surgeon & hospital sued; patient awarded $850,000. Surgeon has no disciplinary record.
14. 2001[24,69]	Rt subdural hematoma. A resident drilled 2 bur holes into wrong side due to CT scan hung backward. Error realized when hematoma was absent & op was completed on correct side. The patient recovered.	1) Failure to mark incision site. 2) Failure to follow hospital policy of multiple surgical site checks *(inadequate preop checks)*.	The state health department investigation determined the hospital failed to follow its own policies of multiple surgical site checks. Surgeon found liable & ordered to study error-prevention methods. Surgeon, 2 surgical residents, OR nurse, OR technologist, RN, & anesthetist referred to licensing boards for investigation. Surgeon has no disciplinary record.
15. 2002[58]	56-year-old female w/ rt temporal lobe intracerebral hemorrhage. Wrong side of head prepped by member of OR team. Anesthesia report indicated that site verification was done. Surgeon operated on incorrect side. Error realized on reaching dura. Hemorrhage was then evacuated from the correct side. CT scan present in OR was hung backwards.	1) CT scan hung backward. 2) Falsely assuming that prepped side was correct side *(communication breakdown & inadequate preop checks)*.	The state board found the surgeon liable for: 1) Breaching the standard of practice. 2) Performing a WSS. The State Board disciplinary ruling: 1) Letter of concern issued. 2) Fined $5000 for the WSS. 3) Fined $3309.12 for administrative costs. 4) 50 hours of community service. 5) 5 hrs of CME on risk management. 6) Present 1-hr lecture/seminar on WSS.
16. 2002[59]	34-year-old female w/ a lt subdural hematoma following MVA. Surgeon prepped & operated on wrong side. Error realized during dictation while patient was still on OR table. Surgeon immediately operated on correct side. The patient died 48–72 hrs later w/ multiple intracranial hemorrhages.		The state board found the surgeon liable for: 1) Breaching standard of practice. 2) Performing a WSS. The state board disciplinary ruling: 1) Letter of concern issued. 2) Fined $7500 for the WSS. 3) Fined $1729.59 for administrative costs. 4) 5 hrs of CME on risk management. 5) Present 1-hr lecture/seminar on WSS.
17. 2002[9]	71-year-old male w/ chronic lt frontal subdural hematoma. Senior resident initiated late-night op on wrong side & drilled 1 bur hole. Error realized & correct side then operated on. Staff neurosurgeon notified & arrived shortly after. Patient made a full recovery.	Patient taken to OR w/out staff neurosurgeon informed *(communication breakdown)*.	Neither patient nor family initiated legal action or submitted any formal complaint.
18. 2002[27]	Unknown diagnosis. Incision made on wrong side of skull.		Unknown

(continued)

TABLE 1: Summary of WSC cases* *(continued)*

Case No. & Year†	Clinical Scenario & Operative Facts	Factors Contributing to the Error‡	Disciplinary Outcome (regulatory board, hospital action, civil litigation)
19. 2003[c]	21-year-old patient w/ rt temporal lobe hematoma. In the ICU, patient's level of consciousness deteriorated quickly. Patient was incorrectly positioned for op & the incision made on incorrect side. Error realized before entering dura & op completed on correct side.	Surgeon alleged incorrect positioning of the patient caused the error *(technical factors)*.	Unknown
20. 2004[54]	55-year-old female w/ lt frontoparietal chronic subdural hematoma. Surgeon prepped, made incision, drilled bur holes & opened dura on wrong side. Surgeon realized & acknowledged the error in OR. Hematoma was immediately evacuated from correct side. Surgeon dictated report stating rt hygroma was present & characterized rt-sided bur holes as planned.	1) Failure to mark incision site. 2) Failure to complete a time-out. 3) Side not indicated on consent form *(inadequate preop checks)*.	The state board found the surgeon liable for: 1) Providing substandard care. 2) Performing a WSS. Surgeon's practice was monitored during the board's investigation & their license was eventually revoked.
21. 2004[16,75,79]	15-year-old male w/ rt temporal epilepsy focus. Incision made, bur holes drilled, & tissue resected from wrong side. Error realized & op completed on correct side. Error not documented in the record. Surgeon disclosed error to parents. Parents alleged error was represented as simple incision on wrong side rather than wrongful "removal & destruction of critical brain tissue." Hospital allegedly did not report the error to JCAHO on lawyers' advice.	1) The op team allegedly did not follow time-out protocol.	Parents filed a civil lawsuit on 3 counts: 1) Battery. 2) Medical malpractice. 3) Willful & wanton infliction of emotional distress. Surgeon settled out of court. Civil lawsuit against an insurance company is ongoing.
22. 2004[28,35]	68-year-old male w/ trigeminal neuralgia. Surgeon began microvascular decompression on wrong side, realized error, & operated on correct side.		Surgeon has no disciplinary record. Patient filed civil lawsuit seeking at least $50,000 each from surgeon & hospital.
23. 2005[28,35]	35-year-old female w/ lt trigeminal neuralgia. Microvascular decompression performed on wrong side. Days later, op repeated on correct side & trigeminal neuralgia was cured; however, patient reported pain at incorrect incision site.	Civil lawsuit alleged surgeon failed to check records before op *(inadequate preop checks)*.	Surgeon has no disciplinary record. Patient filed civil lawsuit seeking at least $50,000 each from surgeon, 2 nurses & the affiliated medical institute.
24. 2006[5,18,81]	Child w/ brain tumor. Surgeons failed to find tumor after removing bone flap. Error realized & tumor resected from correct side. Patient did not experience complications postop.	1) Failure to complete a time-out 2) Failure to mark incision site *(inadequate preop checks)*. 3) A physician moved the OR table causing temporary disorientation *(technical factors)*.	The state health department ordered hospital to submit plan of correction. Hospital implemented new rules: op instruments not allowed in OR before marking incision in the presence of a family member.
25. 2006[60]	77-year-old male w/ a lt subdural hematoma. Surgeon positioned patient & shaved wrong side. Surgeon made incision & drilled bur holes on incorrect side & realized error. Hematoma then evacuated from correct side.		The state board found the surgeon liable for: 1) Breaching the standard of practice. 2) Performing a WSS. The state board disciplinary ruling: 1) Letter of concern issued. 2) Fined $10,000 for the WSS. 3) Fined $3831.18 for administrative costs. 4) 100 hrs of community service. 5) 5 hrs of CME on risk management. 6) Present 1-hr lecture/seminar on WSS.

(continued)

TABLE 1: Summary of WSC cases* *(continued)*

Case No. & Year†	Clinical Scenario & Operative Facts	Factors Contributing to the Error‡	Disciplinary Outcome (regulatory board, hospital action, civil litigation)
26. 2006[38]	Diagnosis unknown. Surgeon summoned for early morning emergency. Operated on wrong side but was eventually credited w/ saving patient's life.		The state board determined mitigating circumstances contributed to the error. Board created remediation plan for surgeon.
27. 2007[41,52,70]	91-year-old male w/ "bleeding in the brain." The resident & nurse performed procedure at the bedside & failed to fill out required form verifying drain location. Drain placed on wrong side. Resident claimed being aware of policy but had never seen the form or anyone use it.	1) Failure to fill out necessary document before a procedure. 2) Failure to complete a time-out *(inadequate preop checks).*	The state health department found that the team failed to complete a time-out in violation of hospital policy. Hospital promised the health department to better educate staff about the documentation policy.
28. 2007[21]	80+-year-old woman w/ acute lt subdural hematoma. Emergency physician mistakenly shaved wrong side. Surgeon operated on incorrect side & realized error when no clot was found. Error explained to family & surgeon operated on correct side. Error led to 40-min delay in hematoma evacuation. Patient reported to be making good progress postop.	Falsely assuming that prepped side was correct side *(communication breakdown & inadequate preop checks).*	Hospital introduced a new set of guidelines requiring surgeons to announce side of op prior to operating.
29. 2007[11,24,38,41,52,70,80]	86-year-old male w/ lt subdural hematoma. Surgeon began op on wrong side. Member of the op team voiced concerns & was ignored. Later, error was realized & op completed on correct side. Patient died 3 wks later (unknown if related to WSC).	1) Failure to confirm site of hematoma w/ imaging, op based on memory. 2) Side of op not indicated on consent form *(inadequate preop checks).* 3) Surgeon ignored team member questioning laterality *(communication breakdown).*	The State Board: 1) Suspended surgeon for 2 mos. 2) Fined surgeon $2000. The state health department ordered hospital to have outside consultant monitor neurosurgery practices & to have 2nd doctor verify each neurosurgery plan. Hospital immediately restricted surgeon's privileges.
30. 2007[10]	46-year-old male w/ lt-sided "blood clot." Surgeons operated on wrong side, realized error & completed op on correct side. Patient reported numbness & scars on both sides of the head & excessive staples & bandaging on discharge.		Patient stated he would initiate a civil lawsuit.
31. 2007[71,72]	19-year-old male w/ a brain tumor. Patient mistakenly taken to wrong OR & underwent knee surgery. Other patient w/ same first name mistakenly underwent brain op instead of knee op. 2 wks later, correct brain op performed & patient died a few hours after the op.	Error attributed to the 2 patients having same first name *(inadequate preop checks).*	Hospital suspended the 2 surgeons involved.
32. 2007[52,53,80,82]	82-year-old female w/ lt-sided "bleeding between brain & skull." A resident & nurse discussed side ahead of time, but for unknown reasons, resident marked wrong side & nurse did not stop him. Resident operated & drilled bur holes on incorrect side. Error realized & op completed on correct side. Patient reported to be stable postop.	Member of the team failed to notify the resident that they were operating on the wrong side *(communication breakdown).*	The state health department reprimanded & fined the hospital $50,000. Hospital issued a statement: "Effective immediately, all intracranial neurosurgery procedures will have an attending physician present for the entire procedure, and the timeout process to verify site and side for significant procedures in the OR or at the bed side will include one physician and a nurse or physician assistant in addition to the resident."

(continued)

TABLE 1: Summary of WSC cases* *(continued)*

Case No. & Year†	Clinical Scenario & Operative Facts	Factors Contributing to the Error‡	Disciplinary Outcome (regulatory board, hospital action, civil litigation)
33. 2008[13,77]	Metastatic tumors. Patient had MRI before Gamma Knife surgery. Entered MRI feet first instead of head first. Medical physicist did not recognize discrepancy when importing images into treatment planning computer. Patient received focused radiation to the wrong side of brain.	Error attributed to non-conventional MRI scanning: feet first instead of head first *(communication breakdown & technical factors)*.	Hospital stated it launched a thorough investigation.
34. yr unknown[d]	Patient w/ rt-sided aneurysm. 4.5 hours into op, surgeon reviewed the CT scan after being unable to find the aneurysm & discovered the error. Surgeon completed op on correct side. The patient was paralyzed on side contralat to actual aneurysm.	The surgeon accepted full responsibility for error.	The patient filed a civil lawsuit.
35. yr unknown[46]	Unknown diagnosis. Patient had bur holes drilled on wrong side due to laterality mix-up in medical record.	Error attributed to laterality mix-up in medical record *(inadequate preop checks)*.	Unknown.

* CME = continuing medical education; ICU = intensive care unit; MVA = motor vehicle accident.

† Location and surgeon names have been purposely deleted.

‡ Italicized points in the "Factors Contributing to the Error" column are assumptions and subjective conclusions made by the authors based on available information. Human error is assumed to be a factor in every case.

[a] C Dubin, personal communication, 2009.

[b] F Bremseth, personal communication, 2009.

[c] S Kudla, personal communication, 2009.

[d] L Turner, personal communication, 2009.

State Medical Licensing Boards

Of the 50 state licensing boards contacted, 20 replied by email. Six state boards were able to report that their state had no cases of WSC on record. An additional 12 state boards reported that they either did not track information regarding WSS or that it was not tracked in a retrievable manner. Two state boards were aware of WSC cases that had been reported in the media.

Factors Contributing To Wrong-Sided Craniotomy

An analysis of the cases revealed 4 categories of factors that contributed to the WSC: 1) communication breakdown; 2) inadequate preoperative checks; 3) technical factors and imaging; and 4) human error. Most cases appear in more than one category because multiple factors contributed to the WSC. Below we discuss how these factors contributed to WSC, using illustrative examples from the cases analyzed.

Communication Breakdown

Communication breakdown was a contributing factor to the surgical errors in eleven cases (Cases 2, 3, 7, 10, 12, 15, 17, 28, 29, 32, and 33). Several of the cases illustrate how inadequate communication within surgical teams and between departments can lead to a WSC. In one case (Case 7), a patient from India was referred to a neurosurgeon by physicians in India. The neurosurgeon was away and his secretary passed on the patient's medical records to another neurosurgeon with instructions to call his colleague. The attending neurosurgeon did not call the referring neurosurgeon. The attending neurosurgeon assumed that the secretary was referring to a different patient of Indian descent who had a brain tumor on the opposite side. The medical records were not reviewed prior to the operation and the operation was carried out on the incorrect side.

In one case (Case 29), concerns were voiced by a member of the team in the OR regarding the laterality of the lesion, but these were ignored and the operation was continued on the wrong side. In another case (Case 32), a resident and a nurse discussed the side of the lesion beforehand; however, when the resident started the procedure on the wrong side, the nurse did not mention that an error was taking place.

Two unique cases demonstrate the importance of communication between departments. In 1980, a Florida hospital acquired a new CT scanner that reversed the previously used laterality convention for CT images (Case 3). The radiology department did not inform the staff at the hospital. The first patient to be scanned in the new CT unit underwent a WSC for a right frontal intracerebral hemorrhage. In a second case (Case 33) involving interdepartmental communication breakdown, a patient undergoing Gamma Knife surgery for a brain tumor received the treatment on the wrong side of the head. During the preoperative MR imaging, the technician scanned the patient feet first instead of head first and failed to notify the radiosurgery team.

Inadequate Preoperative Checks

Inadequate preoperative checks were contributing fac-

tors to the WSC in 17 cases (Cases 1, 2, 4, 7, 10–12, 14, 15, 20, 23, 24, 27–29, 31, and 35). In one case (Case 23), a patient underwent microvascular decompression for trigeminal neuralgia on the incorrect side because the surgeon allegedly failed to check the medical records prior to the operation. Marking the incision preoperatively is increasingly becoming common practice. In at least 5 cases (Cases 1, 2, 14, 20, and 24), failure to mark the incision site before the surgery contributed to the WSC. In one case (Case 29), a surgeon's reliance on memory alone led to the WSC.

The most basic surgical time-out involves verification of the patient's identity, the procedure to be performed, and the side and site of the surgery. Inadequate surgical time-outs were cited as factors contributing to 5 WSCs (Cases 14, 20, 21, 24, and 27). Failure to verify the patient's identity led to one extreme case of WSS. Two patients sharing the same first name underwent the wrong operations; the patient requiring knee surgery received brain surgery and the patient requiring brain surgery underwent knee surgery (Case 31). In several of the WSC cases, a brief surgical time-out confirming the side of the lesion to be treated would have likely prevented the subsequent mistakes. In one case (Case 27), the necessary documents were not filled out prior to starting the procedure, and thus laterality could not be verified if a surgical time-out were initiated. Similarly, in two other cases (Cases 20 and 29), the side of the procedure was not indicated on the consent form.

The absence of imaging during the operation, and failure to verify the correct identity on the images and the positioning of CT scans, led to 6 WSC cases. Failure to have imaging present in the OR during the operation led to 2 WSCs (Cases 4 and 29). In 2 instances, the CT scans present in the OR belonged to different patients (Cases 7 and 11). Computed tomography scans hung backward were contributing factors in 2 other WSCs (Cases 12 and 15).

Technical Factors and Imaging

In a number of cases, a variety of technical factors allegedly predisposed the surgeons to performing a WSC. First, mislabeled images, mislabeled imaging reports, or unconventional acquisition of images were factors in 4 cases (Case 3, 9, 11, and 33). The absence of necessary equipment during the operation was cited as a factor by one surgeon (Case 2). Movement of the OR table or a different OR setup may have contributed to 3 cases (Cases 13, 19, and 24).

Human Error

The common factor in all the cases reviewed was human error. Many of these human errors were preventable with adequate preoperative checks. Inaccurate assumptions contributed to several WSCs. For instance, in 4 cases (Cases 10, 12, 15, and 28), a nurse or physician other than the surgeon prepared the patient for the operation. The surgeons falsely assumed that the correct side had been prepared and began the operations on the incorrect side. Human error may have been more prevalent during emergency situations and during late hours (Cases 8, 9, 12, 16, 17, 26, and 28). Time constraints and fatigue likely increased the probability of performing a WSC.

Clinical Outcomes

In the majority of the cases, the WSC appeared to have had relatively minor impact on the patients' neurological functioning. However, in several cases, patients were left with significant neurological impairments. The degree of impact on clinical outcomes depended on the invasiveness of the procedure. After undergoing a wrong-sided aneurysm repair, one patient (Case 2) reported losing the sense of smell, and another patient (Case 13) experienced seizures, memory deficits, personality changes, and an inability to hold a job. In the latter case, imaging and neuropsychological investigations confirmed brain injury on the side of the WSC. Similarly, in one case (Case 7) in which the patient underwent a WSC for a brain tumor resection, the family reported that the patient had been unable to read or concentrate following surgery, although a state investigation determined that the impact of the WSC on the patient's outcome was unclear. In another case, a patient underwent surgery for a brain cyst that actually belonged to another patient because the CT scan in the OR was of another patient (Case 11). The patient's attorney alleged that his client had a strokelike syndrome including speech deficits. The other patient with the brain cyst in whom surgery was not performed returned to the emergency department weeks later in a coma and subsequently died, presumably due to the delay incurred because the wrong patient received the operation he needed.

In 7 cases, the WSC took place during emergency situations. In these cases (Cases 8, 9, 12, 16, 17, 26, and 28), operating on the wrong side of the skull or brain delayed the intended surgery and may have negatively affected clinical outcomes. These cases illustrate the point that although surgical time-outs and preoperative checks may delay the incision during a surgical emergency, a WSC leads to significantly longer delays and is likely to have a more significant impact on all concerned.

In the majority of the WSC cases, the errors were discovered on reaching the dura and the brain parenchyma was not operated on. Thus, the impact of the WSC was less than if the brain parenchyma had been invaded. However, one patient (Case 23) reported pain at the incorrect incision site, and another patient (Case 30) complained of numbness and scars on both sides of the head. The clinical impact of a WSC extends beyond neurological outcomes; patients may experience unnecessary pain and disfigurement from errant incisions.

Disciplinary Outcomes

The disciplinary outcomes varied widely from case to case in part because administrative disciplinary and litigation policies are state specific and heterogeneous. In many cases, the hospitals and the health departments launched investigations. In some cases (Cases 8, 12, 29, and 31), the surgeons' operating privileges were suspended during or after the investigations. Some hospitals modified their preoperative procedures to prevent further WSC occurrences. In one hospital, a new rule was implemented that prevented surgical instruments from entering the OR before marking of the planned incision in the presence of a patient's family member (Case 24).

In another hospital that had 3 WSCs occur within 1 year, a new policy required the presence of a physician and a nurse or physician's assistant in addition to the resident at the bedside or in the OR during the time-out process and throughout the entire procedure (Case 32).

Following health department investigations, some hospitals were disciplined. The discipline typically consisted of a fine and an order to submit a plan to correct systemic deficiencies. In one case (Case 29), the hospital was ordered to hire an outside consultant to monitor quality of care. The health department also went as far as ordering the hospital to institute a policy requiring a second doctor to verify each neurosurgical operative plan.

From the surgeon's perspective, the medical licensing boards varied substantially in their disciplining procedures. When surgeons were disciplined, the boards typically issued a letter of concern, imposed a fine, and ordered the physician to pay the administrative costs. In Florida, it was common practice to require community service, continuing medical education, and even have the surgeon present a lecture or seminar to the medical community on WSS and systems for prevention (Cases 15, 16, and 25). In general, the surgeons did not have their licenses suspended or revoked after an isolated WSC incident. However, in one case (Case 29) in which the surgeon had performed more than one WSC, the physician's license was suspended for 2 months and then restored. In one hospital, the surgeon was dismissed within a year of the incident (Case 7). In another case, the anesthesiologists in the city refused to work with the surgeon after several surgical errors (Cases 1 and 2). The surgeon sued the anesthesiologists and the hospitals in the city for refusal to provide him with the required anesthesia operative services and he did not prevail.

It is noteworthy that in two cases (Case 12 and 14), members of the OR staff other than the surgeon were investigated or disciplined. In two cases, nurses, anesthesiologists, residents, and technologists were either suspended by the hospital or referred for investigation. These cases demonstrate that responsibility and liability for a WSC can extend beyond the primary surgeon.

Approximately half the cases reviewed led to discoverable or publicized civil lawsuits against the physician or the hospital. The damages awarded to the plaintiffs were as high as $1.775 million (Case 11). In one civil lawsuit, the defendants included nurses present in the OR during the surgery (Case 23). In a case (Case 11) in which a human error by a radiologist contributed to the WSC, the radiologist was also sued.

At the present time, WSC is negligence per se; a WSC is always a breach of the standard of practice and thus WSC is inherently medical malpractice. Interestingly, one early case of WSC discovered was not considered negligence. The case occurred in Florida before WSS became per se negligence; had it occurred today, the outcome would have most certainly been different. A WSC was performed in a patient due to the recent installation of a new CT scanner that reversed the laterality convention (Case 3). The State of Florida Board of Medicine found that the surgeon was not legally responsible for the error. The opinion cited examples of the same error being made across the country, even citing a published editorial titled "Confusion Tomography."[51] Thus, the WSC was not found to fall below the prevailing standard of practice at the time.

Our survey of the state medical licensing boards revealed that there is no standard disciplinary protocol for WSC or WSS in general. The minimum punishments are advisory letters and the maximum punishments are license revocations. The relative infrequency of these WSS events was cited as the rationale for not having standard disciplinary protocols.

Discussion

The review of the cases illustrates the broad range of factors that contribute to WSC. Human error is the most prevalent factor. Systems for prevention such as preoperative checks and time-outs are designed to decrease the likelihood of human error negatively impacting the patient's care. When these preventative systems are bypassed, the chances of performing a WSC increase. Preoperative checks that may have prevented a WSC include the following: 1) preoperative review of the medical records and examination of the patient; 2) confirming the side and site of the operation by speaking to the patient and a family member; 3) marking the surgical site at the time of site confirmation; 4) imaging verification including the correct identity of the patient and that laterality is correctly labeled; 5) the presence of the patient's imaging studies in the OR before and during the operation; and 6) surgical time-outs verifying the patient's identity and the identity on the images, correct positioning of the images, the procedure to be performed, and verifying the site marking. These steps are components of the JCAHO Universal Protocol[33,49] and are endorsed by the American College of Surgeons.[7] The recently developed WHO safe surgery checklist has embraced the majority of these verification procedures.[26] The steps can be broken down into preincision and intraoperative steps.

At the time of obtaining informed consent for the surgical procedure, the side of the operation should be indicated on the consent form. On the day of the operation, the medical record should be reviewed by all members of the surgical team to confirm the laterality of the procedure. At the bedside in the preoperative holding area, the patient's identity should be confirmed using name and date of birth, and the type of procedure should be discussed. The site of the incision should be marked in the presence of the patient and a family member if possible. Anterior incisions can be marked on the forehead and posterior incisions on the back of the neck beyond the hairline.[44] The side of the marking should be compared with information in the medical record.

Some surgical marking practices have been criticized for their vulnerability to errors of interpretation. For instance, if "NO" is used to indicate the nonoperative side, confusion can arise when a surgeon with the initials N.O. signs the correct site.[32] In addition, "NO" inverted vertically may appear to say "ON."[66] The use of an "X" marking can also be ambiguous. The Joint Commission recommends that only the incision site be marked with a "YES" or a line representing the incision site by the sur-

geon performing the operation in a position visible after the patient is prepared and draped, using a marker that will remain visible after prepping. The marking should be carried out with the patient awake, aware, and involved if possible, and the marking procedures should be consistent within an organization.[32]

Imaging errors complicate WSS prevention systems. A major issue is that if the identity of the patient on the scan or the image's laterality is mislabeled, members of the surgical team may not recognize the error even after consulting the medical record. The surgical team is at the mercy of the CT or MR imaging technician. Therefore, the imaging used for the operation must be correctly labeled. If a discrepancy between the image and the medical record is discovered, repeating the imaging is recommended. This practice has led to the prevention of one wrong-level spine surgery.[8] An automated system for confirming accurate labeling of imaging laterality exists.[14] This software can determine laterality of images with 100% sensitivity and 98% specificity. Laterality on imaging can also be double checked by placing a fiducial or vitamin E tablet on the side of the lesion or pathological entity during preoperative MR imaging. For instance, a patient with trigeminal neuralgia on the left side can place a vitamin E tablet on the site of neuropathic pain, and this marker will be visible on the MR images obtained throughout the operation. This practice is routine in some radiosurgery centers. When a patient has a diagnosis that does not involve an anatomical lesion present on imaging (such as functional or epilepsy surgery), marking the correct side of the pathological entity in advance is especially important.

In the OR, immediately prior to the surgery, a surgical time-out must take place. The JCAHO requirements state that during the time-out, the following information must be confirmed: the patient's identity, the side and site of the surgery, and the procedure to be done. During the time-out, the imaging in the OR should also be verified. The imaging should be of the correct patient and be consistent with the correct side and site of the preoperative incision marking. Although there is no gold standard on when a time-out should be completed, British guidelines suggest the time-out should take place in the OR before final positioning, the insertion of head pins, or making the incision.[44]

During the operation, the use of image-guided technology (that is, surgical navigation system, frameless stereotaxy) can further decrease the likelihood of performing a WSC.[9] These surgical navigation systems can visually depict the side of a lesion (or the side of the marker when no lesion is present) once the patient has been positioned for the operation. Although this technology is commonly available in many neurosurgical centers in developed countries, it is not always routinely used, may not be available after hours, and may be financially impractical in some centers.

At present, reporting of WSS errors is inadequate. Even when state boards collect this information, the data are largely inaccessible. The development of preventative strategies depends on reporting of incidents and thorough error analyses. There are several barriers to reporting including the stigma associated with error and the fear of medicolegal action. This is evidenced by the fact that only one wrong-side brain surgery has been reported in a peer-reviewed surgical journal.[9] One alternative is mandatory reporting, which has been legislated for surgical errors in 4 states (Florida,[56] Indiana,[29] Minnesota,[42] and Pennsylvania[47]). Canada and the United Kingdom have not instituted mandatory reporting, although the United Kingdom National Patient Safety Database is the largest of its kind in the world and regulatory agencies in the United Kingdom have released statements about addressing the issue of underreporting.[22] To address surgical errors, the medical community must embrace openness when it comes to errors. Ideally, reporting systems should record errors prospectively to allow clarification of even long-term complications. A prospective error-reporting system can and has been implemented in at least one neurosurgical practice.[65]

In the end, human error is inevitable. The goal of prevention systems is to institute protocols that minimize the likelihood of human error negatively affecting patient care. Some factors contributing to WSC are understandable, such as afterhours operations, time constraints in emergency situations, and fatigue.[30] However, many WSCs that have occurred in the past could have been prevented with strict, comprehensive, and thorough protocols and procedures. Although these systems may seem cumbersome, if implemented universally and practiced routinely, they would add minimal additional time to each procedure and they would decrease the frequency of WSCs and their corresponding clinical and legal implications in most cases. In other industries, thorough error analyses and the implementation of error-prevention systems have substantially decreased the incidence of errors. In aviation, pilot error decreased 40% over 2 decades, in part due to mandatory reporting of accidents, rigorous error analyses, and carefully crafted error-prevention systems.[6] Inadequate reporting has hindered the medical profession's ability to assess the factors contributing to surgical errors and to design effective strategies for prevention. In dealing with individual human lives, we should be at least as vigilant and proactive as the airline industry in terms of reporting, investigation, analysis, and remediation.

Limitations

The acquisition and analysis of the information gathered for this case review was complicated by several factors. First, a significant amount of information obtained was based on media reports. We acknowledge the potential lack of reliability inherent in media reporting.

In many cases, despite the reporting of civil litigation in the media, legal documents were unobtainable for multiple reasons including out-of-court settlements, confidentiality agreements, and other logistical issues. Arguably the most significant limitation of this study is the underreporting of WSCs. These limitations highlight the importance of openly sharing information regarding WSS cases to perform thorough analyses and design preventative strategies.

Conclusions

Wrong-site craniotomies still occur despite the imple-

mentation of surgical checklists and preventative protocols. Communication breakdown and inadequate preoperative checks are modifiable risk factors for WSC. Vigilant adherence to preoperative checks and surgical time-outs is crucial for preventing WSCs. The clinical outcomes are often relatively minor; however, this surgical error can lead to devastating consequences. At present, reporting of surgical errors is insufficient to fully address the complicated nature of this problem. The surgical community must embrace a culture of openness and understanding toward errors to move forward and ultimately improve the quality of patient care. Wrong-site craniectomies are an error that should be eradicable.

Disclosure

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author contributions to the study and manuscript preparation include the following. FL Cohen developed the idea for the paper, collected cases and information, wrote the first draft, and contributed to the final editing of the paper. D Mendelsohn revised the first draft, collected cases and information, and contributed to the final editing of the paper. M Bernstein revised the first draft and contributed to the final editing of the paper. FL Cohen, D Mendelsohn, and M Bernstein reviewed the final version of the manuscript and approved the submission.

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From the Editor-in-Chief: The references in this article are not provided in the standard format. The present format was used to protect the patients, surgeons, and hospitals. *Abbreviations:* XXX = surgeon's name; YYY = hospital's name; ZZZ = patient/family's name.

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