Errors in Neurosurgery

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KEYWORDS

- Medical error • Surgical error • Quality improvement • Patient safety • Wrong-sided surgery
- Sentinel event

KEY POINTS

- Medical errors are common and serious, leading to an estimated 440,000 deaths annually in the United States.
- For neurosurgery patients, prospective studies found errors in 25% to 85% of all cases.
- Only 25% of recorded errors are caused by surgical technique; most errors involve the whole health care team, highlighting the importance of systems thinking.
- A wide range of tools has been developed to help reduce the frequency and impact of errors, such as the World Health Organization's Surgical Safety Checklist, computerized order entry, and surgical navigation systems.

INTRODUCTION

Despite their training and intentions, health care workers will inevitably make mistakes when caring for patients. Some of these errors can be serious and life threatening, while others are near misses, identified early and fixed before they cause harm. Understanding the frequency and danger posed by medical errors, and offering strategies to prevent them, forms the basis of the modern patient safety movement.

Neurosurgery is far from immune to these errors. The complexity of neurosurgical patients and the interdisciplinary teams required to manage their conditions expose these patients to the same errors found in other medical and surgical specialties, along with errors unique to neurosurgery.

DEFINITION AND CLASSIFICATION OF ERRORS

Medical errors have been defined in various ways, but at their core, they are acts of omission or commission that cause harm or have the potential to cause harm to patients.[1,2] This definition was elaborated in the neurosurgical literature by Stone and Bernstein as any act of omission or commission resulting in deviation from a perfect course for the patient. A perfect course was defined as one in which nothing went wrong, from the smallest detail (such as dropping a sponge) to the most obvious example (that is, one that every neurosurgeon would easily recognize, like wrong-sided surgery).[3,4]

Importantly, patient safety studies differentiate errors from adverse events (**Fig. 1**), which are inadvertent injuries resulting from medical care, or the failure to deliver medical care.[5–7] Errors have the potential to cause harm, while adverse events are harm. In other words, errors can lead to adverse events if they are not caught first (ie, a near miss[8]), but adverse events can also occur without errors (ie, a nonpreventable adverse event, such as a hemorrhage following a perfectly executed external ventricular drain placement).
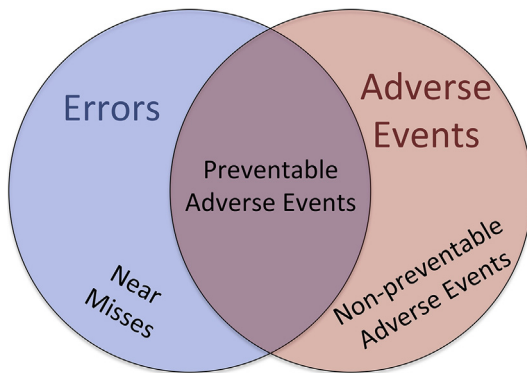
Fig. 1. Relationship of errors to adverse events. Errors are acts of omission or commission that cause harm or have the potential to cause harm to patients. Adverse events are inadvertent injuries resulting from medical care, or the failure to deliver medical care, and can be classified further as preventable or nonpreventable. Near misses are errors that are caught before they can cause injury to a patient.

Errors are further divided into active errors (or sharp-end errors) and latent errors (or blunt-end errors).[9] Active errors are the most recognizable, usually involving a frontline health care worker directly interacting with a patient, such as a surgeon injuring the carotid artery during an aneurysm clipping, or an anesthesiologist connecting the incorrect gas anesthetic, isoflurane in place of oxygen, to an anesthesia machine.[10] Latent errors, on the other hand, refer to errors within the system makeup itself (including bureaucracy, facilities, equipment, or organization) that permit other errors to occur. In the specific case of anesthesia gases noted previously, modern anesthesia machines have specialized connectors (the pin index safety system) that allow only the correct gas cylinder to be hooked up (eg, only oxygen canisters can link to the oxygen intake), which have almost eliminated this type of error.[11]

Active errors are frequently studied in psychology, and classifications have been proposed to subdivide errors and identify common error-generating mechanisms. Perhaps the best known is James Reason's classification of active errors into slips and mistakes.[12] Slips occur when planned actions are not executed correctly—as in literally slipping with a scalpel. Mistakes occur when an incorrect action is selected, even if executed perfectly, such as wrong-sided surgery.

An example of a more complex classification of errors is the National Coordinating Council (NCC) for Medication Error Reporting and Prevention, which separates errors into 9 classes (A through I) according to how much harm was caused, where class A is no error and class I is an error potentially

contributing to a patient's death.[9] Notably, the NCC classification divides errors by their effects; Reason's classification divides errors by their mechanisms.

EPIDEMIOLOGY OF ERRORS

The modern patient safety movement arguably began with the publication of the Institute of Medicine's (IOM's) *To Err is Human*, in 1999.[9,13] This study, relying on the Harvard Medical Practice Study,[7] estimated that between 44,000 and 98,000 Americans were killed each year by medical errors.[13] This figure led to the alarming jumbo jet comparison, where the number of deaths caused by medical errors was likened to 1 passenger jet crashing daily.[9] The mortality estimates from the IOM's report have since been revised still higher, with up to 440,000 deaths caused by medical errors per year.[14] The conservative economic cost of such errors is estimated at $17 billion to $29 billion.[15]

Errors affect all aspects of the medical system, from medication administration to surgical procedures. In the perioperative period, an estimated 3% of patients suffer an adverse event, half of which are preventable.[16] Over 14% of neurosurgical patients, in particular, suffer one or more perioperative complications, many of which are preventable.[17] Wrong-side or wrong-patient procedures occur in roughly 1 case out of every 100,000 operations, and in 2.2 cases of every 10,000 craniotomies.[18] Surveys of neurosurgeons show that 25% of physicians have made an incision on the wrong side of the head, and 35% admitted to wrong-level lumbar surgery in their careers.[19] Unintentionally retained equipment (eg, instruments and sponges) mar about 1 of every 5500 to 10,000 operations.[9]

Only a few studies have analyzed errors specifically in neurosurgical patients. Stone and Bernstein reported on the prospective collection of error data in neurosurgery patients over a 7-year period from 2000 to 2006[4] and Oremakinde and Bernstein incorporated data from the prior study,[3] and reported their experience cataloging errors from 2000 to 2013, where all errors were prospectively logged by the senior author for 2082 of his cases.[3] Errors occurred in 85.3% of cases; 24.2% were due to contamination. Twenty-four percent were due to technical errors, and 22.4% equipment failure or missing equipment. The remainder were due to delays, nursing, anesthesia, or other sources[3]; 54.2% of these errors had no or minimal clinical significance.

Bostrom and colleagues[20] also prospectively cataloged errors from neurosurgical procedures