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Major and minor complications in extraoperative electrocorticography: A review of a national database

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ABSTRACT

The risk profile of extraoperative electrocorticography (ECoG) is documented almost exclusively by case series from a limited number of academic medical centers. These studies tend to underreport minor complications, like urinary tract infections (UTIs) and deep venous thromboses (DVTs), that nevertheless affect hospital cost, length of stay, and the patient's quality of life. Herein, we used data from the American College of Surgeons (ACS) National Surgical Quality Improvement Program (NSQIP) to estimate the rate of adverse events in extraoperative ECoG surgeries. NSQIP is a validated dataset containing nearly 3 million procedures from over 600 North American hospitals, and uses strict criteria for the documentation of complications. Major complications occurred in 3.4% of 177 extraoperative ECoG cases, while minor complications occurred in 9.6%. The most common minor complication was bleeding requiring a transfusion in 3.4% of cases, followed by sepsis, DVT, and UTI each in 2.3% of cases. No mortality was reported. Overall, in a national database containing a heterogeneous population of hospitals, major complications of extraoperative ECoG were rare (3.4%). Complications such as UTI and DVT tend to be underreported in retrospective case series, yet make up a majority of minor complications for ECoG patients in this dataset.

Introduction

Extraoperative electrocorticography (ECoG) is a means of obtaining high quality electroencephalographic data that can then be used to localize otherwise occult seizure foci (Lee et al., 2000; Rolston et al., 2015; Vale et al., 2013; Van Gompel et al., 2008). Without the critical information ECoG provides, many patients would not be candidates for surgery, since no definitive seizure onset zone would be recognized. Yet all surgeries carry risk. Reported case series of ECoG procedures are typically from high-volume academic centers, and often fail to report minor complications like urinary tract infections (UTIs), deep venous thromboses (DVTs), and pneumonias. Though such complications are minor, they nevertheless contribute to increased costs, longer inpatient stays, and worsened quality of life.

In 2005, the American College of Surgeons (ACS) created the National Surgical Quality Improvement Program (NSQIP) in an effort to identify and prevent perioperative complications (Ingraham et al., 2010; Khuri, 2005; Rowell et al., 2007). NSQIP contains a database of nearly 3 million surgical procedures from over 600 hospitals primarily in the United States, but also Mexico and Canada. The group of hospitals contains a heterogeneous collection of academic and private centers, as well as low- and high-volume hospitals. Data are entered prospectively by trained and frequently audited personnel. Strict criteria are used for complications, which are tracked for the 30 days following surgery. For instance, to qualify as a deep venous thrombosis (DVT), the diagnosis must be confirmed by imaging (duplex ultrasound, venogram, CT scan, or other definitive modality) and the patient must be treated for the DVT (or document their informed decision to refuse treatment). Asymptomatic events would not be included, nor would clinically presumed but not confirmed cases. These strict criteria will likely lead to a conservative underestimation of many complications.

Another advantage of NSQIP is the use of Current Procedural Terminology (CPT) codes for identifying surgical procedures. This compares to other databases, like the Nationwide Inpatient Sample (NIS), which only use International Classification of Diseases (ICD-9) billing codes. The ICD-9 code for ECoG (02.93), for example, is non-specific: "Implantation, insertion, placement, or replacement of intracranial: brain pacemaker [neuropacemaker], depth electrodes, epidural pegs, electroencephalographic receiver, foramen ovale electrodes, intracranial electrostimulator, subdural grids, subdural strips" (Rolston et al., 2015) This is the same ICD-9 code used for deep brain stimulation (DBS) and many other indications.

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Table 1
CPT codes for ECoG surgery.

CPT code	Description
61531	Subdural implantation of strip electrodes through one or more burr hole for long-term seizure monitoring
61533	Craniotomy with elevation of bone flap; for subdural implantation of an electrode array, for long-term seizure monitoring
61535	Craniotomy with elevation of bone flap; for removal of epidural or subdural electrode array, without excision of cerebral tissue (separate procedure)
61760	Stereotactic implantation of depth electrodes into the cerebrum for long-term seizure monitoring

Therefore, the documentation of concurrent ICD-9 codes (like refractory epilepsy) is required to ensure that only ECoG cases are extracted. This is an imperfect method, and excludes cases where additional diagnoses are not explicitly entered by billing personnel. CPT codes help in this regard due to their specificity. For example, there are four specific codes for ECoG surgery (see Table 1).

Using NSQIP, we investigated the rate and type of perioperative complications for extraoperative ECoG. This allowed us to compare the observed rate from this heterogeneous hospital sample, compared to historical reports from academic high-volume centers.

Materials and methods

CPT codes were used to extract all ECoG procedures performed between 2005 and 2013 from the NSQIP database (Table 1). Some of the complications documented in NSQIP might reflect preexisting conditions. For instance, one tracked complication is ventilator dependence for longer than 48 h postoperatively. If a patient was ventilator-dependent preoperatively, however, this postoperative event is likely a reflection of a preexisting condition, rather than a new postoperative complication. Therefore, we excluded complications when associated preexisting conditions were present. However, if it took more than 48 h for the condition to develop and be documented, it was unlikely present at the time immediately before surgery, and therefore included as a complication. Note that this restriction was only for potential preexisting complications—all complications without evidence of preexisting conditions were included, regardless of timing (0 to 30 days postoperatively). This correction for potential preexisting conditions was done for the following complications: superficial surgical site infection (SSI), deep incisional SSI, organ space SSI, pneumonia, ventilator-dependence >48 h postoperatively, progressive renal insufficiency, acute renal failure, coma lasting >24 h, sepsis, and septic shock. Additional complications were identified by examining the postoperative diagnosis; this identified 3 cases of subdural hematoma and one of spinal fluid leak.

Complications were classified as major or minor, following prior studies of epilepsy surgery (Bjellvi et al., 2015; Hader et al., 2013). In short, major complications were defined as those likely to produce effects persisting >3 months, while minor complications were those expected to resolve in <3 months.

Statistical analysis was performed with version 23 of SPSS (IBM; Armonk, NY, USA). Averages were presented with standard deviation (SD) unless otherwise specified. Multivariate regression was done using the backward Wald method, an exclusion cut-off of 0.05 and a maximum of 200 iterations.

Results

Using the CPT codes for ECoG surgery (Table 1), 177 cases of extraoperative ECoG were extracted from the NSQIP database between the years 2005 and 2013. Most of these procedures were for craniotomies and placement of subdural electrodes (67.8%), with burr holes and stereotactic placement (SEEG) less frequent (Table 2).

Table 2
Frequency of procedures from 2005 to 2013.

Procedure	Number of procedures	Frequency
Burr hole for subdural electrodes	30	16.9
Craniotomy for subdural electrodes	120	67.8
SEEG	9	5.1
Removal of electrodes	33	18.6
Total	177	

Table 3
Postoperative diagnoses.

Diagnosis	Number (%)
Localization-related, complex partial seizures	86 (48.6)
Unspecified epilepsy	42 (23.7)
Localization-related, simple partial	26 (14.7)
Generalized convulsive seizures	7 (4.0)
Brain tumor	6 (3.4)
Subdural hemorrhage	3 (1.7)
Generalized non-convulsive epilepsy	1 (0.6)
Device complication	1 (0.6)
Other	3 (1.7)

Each procedure in the NSQIP database reports a single postoperative ICD-9 diagnosis. For ECoG, the most common diagnosis was localization-related complex partial seizures (48.6%). These postoperative diagnoses also identified 3 removals of ECoG arrays for subdural hematomas, and one spinal fluid leak requiring repair (Table 3).

Complications were documented in 21 of 177 patients (11.9%; Table 4). Major complications were rare (3.4%), while minor complications occurred in 9.6% of cases. The most common minor complication was bleeding requiring a transfusion (3.4%), followed by sepsis, DVT and UTI, each in 2.3% of cases (Table 4).

Univariate analysis was used to identify potential predictors of complications. Short stature and Asian race were significantly associated with complications by this method (Table 5). Multivariate analysis was then used to account for possible cofounders.

Table 4
Frequency of complications.

Complication	Number of patients (%)
Major	
Subdural hematoma	3 (1.7)
Stroke	1 (0.6)
Organ space SSI	1 (0.6)
Attempted suicide	1 (0.6)
Total major	6 (3.4)
Minor	
Bleeding requiring transfusion	6 (3.4)
Sepsis	4 (2.3)
DVT	4 (2.3)
UTI	4 (2.3)
Wound disruption	2 (1.1)
Spinal fluid leak requiring repair	1 (0.6)
Progressive renal insufficiency	1 (0.6)
Unplanned reintubation	1 (0.6)
Pneumonia	1 (0.6)
Superficial SSI	1 (0.6)
Total Minor	17 (9.6)
Any complication	21 (11.9)[a]

SSI = surgical site infection; UTI = urinary tract infection; DVT = deep venous thrombosis.

[a] Note that 3 patients had both major and minor complications, therefore the total number of patients with "Any complication" is lower than the sum of *Total major* and *Total minor* to avoid double counting.