

# Complication Rates of Subdural versus Depth Electrodes in 175 Patients Undergoing 210 Procedures for Invasive Monitoring in Epilepsy

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# Introduction

Intracranial monitoring has remained fundamental to epilepsy surgery. Associated complications include cerebral edema, subdural hematoma, epidural hematoma, infection, and cerebrospinal fluid (CSF) leak; which have a combined reported rate of 5-17%. Although several studies have highlighted risk factors such as number of implanted electrodes, number of trephinations, and occipital location, the risk associated with each electrode type has yet to be reported.

### Methods

Under IRB approval, we conducted a retrospective review of 175 consecutive patients with drug-resistant epilepsy who underwent a total of 210 electrode implantation procedures between 2003 and 2011 at the Thomas Jefferson Comprehensive Epilepsy Center. Medical records were reviewed to obtain epilepsy histories and details of each patient's hospital course. Postoperative CT scans and MRIs sequences routinely obtained within the first two days of implantation were reviewed to verify radiographic findings previously documented by a Neuroradiologist. Whenever possible, findings were attributed to a particular electrode type based on their relative location to implanted electrodes; those without a clear association were considered unclassifiable.

All analyses were performed using the Regression Modeling Strategies (RMS) package in R (R Foundation for Statistical Computing, Vienna, Austria). A full logistic regression model was created from all potential predictors and variables were systematically eliminated using the Akaike Information Criterion (AIC) until no further improvement was noted in the AIC.

# Results

This cohort included 95 men and 80 women

ages  $34\pm13$  implanted with 1932 subdural electrodes (SDEs) and 451 depth electrodes (DEs) for  $14.1\pm8.6$  days (3-54 days). The majority (76.1%) of radiographic findings were asymptomatic, particularly for extraaxial collections, contusions, and edema. A total of 26 complications were documented and their distribution is shown in Table 1.

Table 1				
	Subdural Electrode	Depth Electrode	Unclassifiable	
Procedures	210	98		
		2383		
Number of Electrodes	1846 strips 86 grids	451		
Hemorrhage				
Total	37 (1.9%)	6 (1.3%)		
Asymptomatic	32 (1.7%)	5 (1.1%)		
Symptomatic	5 (0.3%)	1 (0.2%)		
Infarcts			1000000000000	
Total	7 (0.4%)	1 (0.2%)	1 (0.5%)	
Asymptomatic	4 (0.2%)	1 (0.2%)	1 (0.5%)	
Symptomatic	3 (0.2%)	0 (0.0%)	0 (0.0%)	
Cortical Contusion				
Total	14 (0.7%)	1 (0.2%)		
Asymptomatic	13 (0.6%)	1 (0.2%)		
Symptomatic	1 (0.1%)	0 (0.0%)		
Cerebral Edema				
Total	8 (0.4%)	1 (0.2%)		
Asymptomatic	7 (0.4%)	1 (0.2%)		
Symptomatic	1 (0.1%)	0 (0.0%)		
Extra-Axial Collection				
Total	28 (14.5%)			
Asymptomatic	24 (12.4%)			
Symptomatic	4 (0.2%)			
Intraparenchymal SDE				
Total	5 (0.3%)			
Asymptomatic	4 (0.2%)			
Symptomatic	1 (0.1%)			
Electrode Dislodged				
Total	0 (0.0%)	2 (0.4%)		
Asymptomatic	0 (0.0%)	2 (0.4%)		
Symptomatic	0 (0.0%)	0 (0.0%)		
CSF Leak				
Total	4 (0.2%)	0 (0.0%)	2 (1.0%)	
Treated Conservatively	3 (0.2%)	0 (0.0%)	1 (0.5%)	
Requiring Lumbar Drain or Repair	1 (0.1%)	0 (0.0%)	1 (0.5%)	
Fever/Infection				
Total	13 (0.7%)	0 (0.0%)	14 (6.7%)	
Culture Negative Fever without Intervention	5 (0.3%)	0 (0.0%)	9 (4.3%)	
Prophylatic Explantation	3 (0.2%)	0 (0.0%)	3 (1.4%)	
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Composition of findings and complications. Symptomatic and clinically relevant complications are in red. Percentages in parentheses indicate associated risk per electrode except for the third column in which indicates risk per case.

Intracranial hemorrhage (ICH) was the most common finding, but only 6 (4.2%) resulted in neurologic deficits, of which 3 resolved. Although 27 (18.8%) of procedures were associated with a postoperative fever or infection, only 7 (4.9%) were culture-proven infections requiring long-term antibiotics. Complications per SDE were 0.3% hemorrhage, 0.2% infarct, and 0.2% subdural collection; and per DE were 0.2% hemorrhage and 0% infarct. [Figure 1] In-hospital complications not directly related to electrode implantation included deep vein thrombosis (5), urinary tract infections (4), oral abscesses (1), kidney stones (1), status epilepticus (1), and death from cardiac failure (1).



This hemorrhage associated with left temporal DEs was the sole complication for this series of 451 implanted DEs.

Logistic regression models revealed significant predictors for radiographic ICH and for radiographic extra-axial collections. [Table 2]

Prior craniotomy was the most significant risk factor for radiographic ICH (OR=4.02) followed by a concurrent resective procedure (OR=2.75). For radiographic extra-axial collections, the most significant risk factor was the number of subdural grids implanted (OR=2.14).

Table 2					
Radiographic Hemorrhage					
	OR	95% CI	p-value		
Prior Craniotomy	4.02	1.57-10.32	0.004		
<b>Concurrent Resection</b>	2.75	0.98-7.69	0.054		
# Depth Electrodes	1.30	1.10-1.55	0.002		
Radiographic Extra-Axial Collection					
	OR	95% CI	p-value		
# SD Grids	2.14	1.25-3.67	0.006		
Days Implanted	0.95	0.88-1.02	0.125		

Odds ratios calculated from logistic regression analysis model. Only prior craniotomy, concurrent resection, and number of depth electrodes were found to be associated with postoperative radiographic hemorrhage. Only the number of subdural grids and duration of implantation were found to be associated with postoperative radiographic extra-axial

collections. No significant risk factors were found for symptomatic lesions.

#### Conclusion

In the largest series of implanted electrodes reported to date, the cumulative complication rate of 10% is consistent with prior reports and upholds the overall safety of chronic invasive monitoring. Patients with prior craniotomies and a greater volume of implanted hardware appear to have higher complication rates. Further analysis has revealed overall complication rates of 1.2% per SDE and 0.2% per DE. In patients implanted with both electrode types, it was not possible to attribute a fever or infection a SDE or DE. While we recognize that this group of complications may equalize complication rates per electrode type if attributed entirely to DEs (1.2% per SDE, 1.3% per DE), the likelihood that DEs alone were responsible for all of these complications is highly improbable. Ultimately, possible explanations for the difference in complication rates between electrode types include increased micromotion, greater contact with pial vasculature, and greater mass effect of SDEs relative to DEs.