



# Neuromonitoring Using Motor and Somatosensory Evoked Potentials in Aortic Surgery

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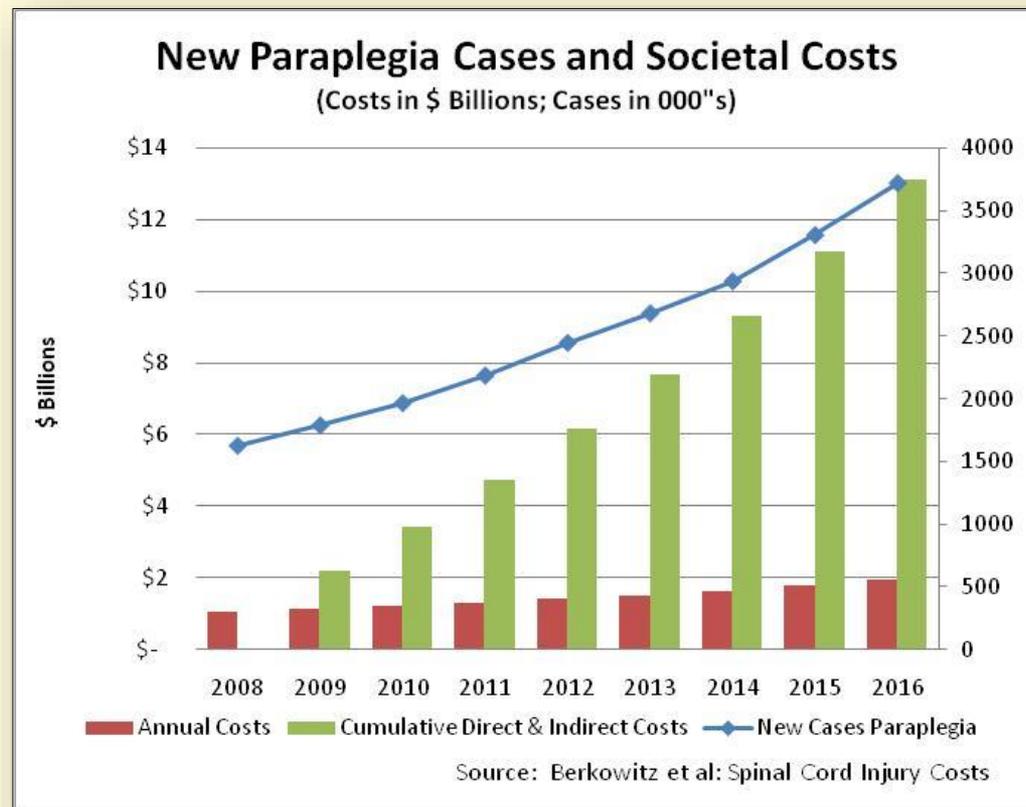
*Presented at the 5th International Meeting on Aortic Diseases  
Liège, Belgium*

*September 16<sup>th</sup>, 2016*

# Paraplegia Continues

- **Paraplegia continues to occur, despite advances in prevention, including:**
  - LA-FA Bypass (left heart bypass)
  - Spinal fluid drainage
  - Maintenance of high perfusion pressure
  - Identification/preservation of spinal artery
- **Complicates both types of procedures:**
  - Open – 10% (Crawford II and III)
  - Endovascular – 5%

# Incidence of paraplegia related to aortic surgery is increasing, as number of cases grows



# Reported Rates of Paraplegia

Author (year)	Institution	No. of Pts.	Incidence of spinal cord injury with permanent dysfunction					Comments
			Descending thoracic	Crawford I	Crawford II	Crawford III	Crawford IV	
Coselli (2007) [1]	Texas, Baylor	2286	Not reported	3.3% (23/706)	6.3% (48/762)	2.6% (10/391)	1.4% (6/427)	
Zoli (2008) [2]	Mount Sinai	609	2.3% (7/304)	2.5% (3/121)	11.5% (7/61)	3.9% (3/77)	2.2% (1/46)	2.3% (20 cases of paraplegia in 858) [3]
Greenberg (2008) [4]	Cleveland	372	1% (1/136)	14% (7/51)	22% (13/59)	10% (6/62)	2% (1/64)	
Conrad (2008) [5]	MGH	471	7% (7/93)	24% (14/58)	20% (13/65)	13% (21/156)	2% (2/99)	
Fehrenbacher (2010) [6]	Indianapolis	343	1.0% (1/98)	4.3% (3/69)	5.4% (6/111)	3.1% (1/32)	0 (0/33)	DTA + Type I 2.4% (4/167)
Kulik (2011) [7]	St Louis	218	Not reported	1.8% (1/57)	5.5% (5/91)	5.7% (4/70)	4.6% (10/70)	5.3%(13/243), 9 paraplegia, 4 paraparesis [8]
Lima (2012) [9]	Cleveland	330	8.3% (9/108)	10.0% (9/90)	10.6% (9/85)	12.2% (5/41)	0 (0/7)	
LeMeire (2012) [10]	Texas	823	Not reported	3.3% (7/209)	5.6% (15/264)	8.9% (14/157)	3.1% (6/193)	Jan 2005-May 2012
Tanaka (2015) [11]	Japan	100	Not reported	0 (0/13)	2.6% (2/76)	0 (0/11)		
Coselli (2015)	Texas, Baylor	3264	Not reported	3.2% (29/907)	8.0% (84/1047)	6.7% (44/652)	2.4% (16/658)	2015 AATS meeting

# Selecting an intraoperative monitoring protocol

- **Transcranial Motor Evoked Potentials (MEP)**
  - Compound muscle action potentials recorded from peripheral muscles following transcranial electrical stimulation of the motor cortex
  - Monitors the corticospinal tracts and anterior horn motor neuron function
- **Somatosensory Evoked Potentials (SSEP)**
  - Recorded over the scalp in the somatosensory cortex following electrical stimulation of peripheral nerves
  - Monitors the dorsal column of the spinal cord

# MEP Technical Set Up



# Why are MEPs necessary?

1. Anatomic separation of dorsal columns and the motor pathway
2. Distinctly different vascular supplies for the anterior and posterior spinal cord
3. Anterior spinal cord is more sensitive to ischemia due to a poorer anastomotic network than the posterior spinal cord
4. Motor gray matter in the spinal cord is more sensitive to ischemia than the dorsal column white matter axons

# Pre-operative considerations

- **Patient Interview and Exam**
  - Neuro exam
  - Contraindications for running MEPs
  - International 10-20 system head measurement
- **Communication with the anesthetic team**
  - Total intravenous anesthesia preferred
  - Multiple train MEPs are generally obtainable with low dose of inhalation agent (<.5 MAC), however this is patient dependent.
  - Effects of opioids are minimal on evoked potentials
  - No relaxant generally preferred
  - MEPs can be run under controlled partial NMB

# Neuromonitoring Using Motor and Somatosensory Evoked Potentials in Aortic Surgery

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**ABSTRACT** *Background:* Motor evoked potentials (MEP) and somatosensory evoked potentials (SSEP) are established methods of neuromonitoring aimed at preventing paraplegia after descending or thoracoabdominal aortic repair. However, their predictive impact remains controversial. The aim of this study was to evaluate our single-center experience using this monitoring technique. *Methods:* Between 2009 and 2014, 78 patients (mean age  $66 \pm 12$ , 53% male) underwent either descending or thoracoabdominal aortic repairs. Of these, 60% had an aortic aneurysm, 30% dissection, and 10% other etiologies. Intraoperatively, MEPs and SSEPs were monitored and, if necessary, clinical parameters (blood pressure, hematocrit, oxygenation) were adjusted in response to neuromonitoring signals. This analysis is focused on the neurological outcome (paraplegia, stroke) after the use of intraoperative neuromonitoring. *Results:* Thirty-day mortality was 10 (12.8%). All patients with continuously stable signals or signals that returned after signal loss developed no spinal cord injury, whereas two out of six of the evaluable patients with signal loss (without return) during the procedure suffered from postoperative paraplegia (one transient and one permanent). Sensitivity and specificity of use of MEP and SSEP were 100% and 94.20% regarding paraplegia, respectively. *Conclusions:* (1) Preservation of signals or return of signals is an excellent prognostic indicator for spinal cord function. (2) Intraoperative modifications in direct response to the signal change may have averted permanent paralysis in the patients with signal loss without neurologic injury. We have found MEP and SSEP neuromonitoring to be instrumental in the prevention of paraplegia. doi: 10.1111/jocs.12739 (*J Card Surg* 2016;31:383–389)

# Patient profile

- 78 patients with Desc/TAAA surgery
- 2009-2014 period
- Mean age  $66 \pm 12$  years (range 37–86)
- 37 female patients (47%)
- Etiologies:
  - Aneurysm – 47 patients (60%)
  - Dissection – 23 patients (30%)
  - IMH – 4 patients (5%)
  - Other (PAU, etc.) – 4 patients (5%)

# Localization of the Spinal Arteries

**TABLE 2**  
**Spinal Artery Location by Preoperative Spinal Cord CT Angiogram**

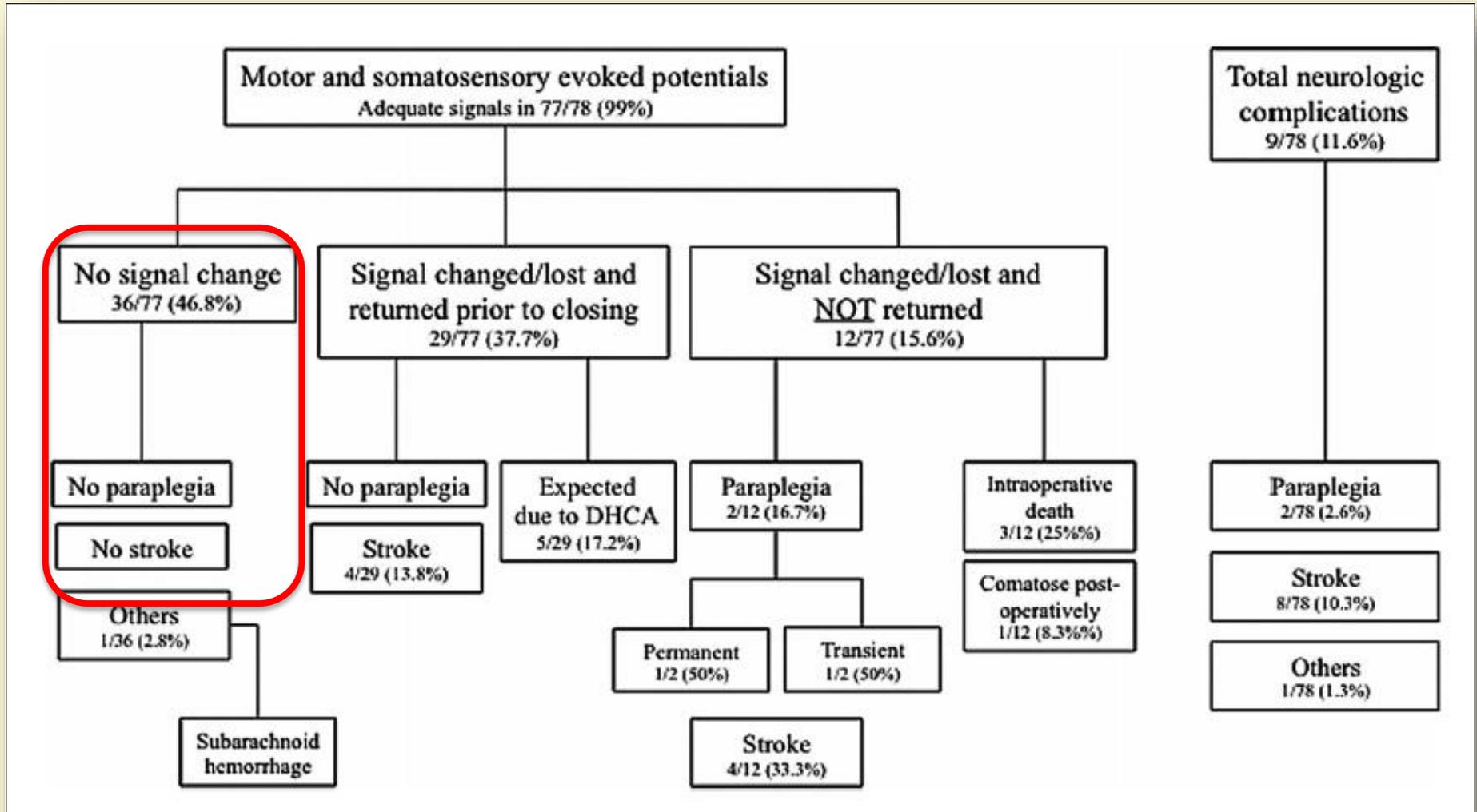
	<b>T8</b>	<b>T9</b>	<b>T10</b>	<b>T11</b>	<b>T12</b>	<b>L1</b>	<b>Unable to Visualize</b>
Location of spinal artery	2	18	27	25	18	10	11

Preoperative CT angiogram was performed in 68 (87%) out of 78 patients. Spinal arteries were visualized in 57 patients; in some patients, more than one spinal artery was visualized. In the remaining 11 patients, we were unable to visualize spinal arteries at all.

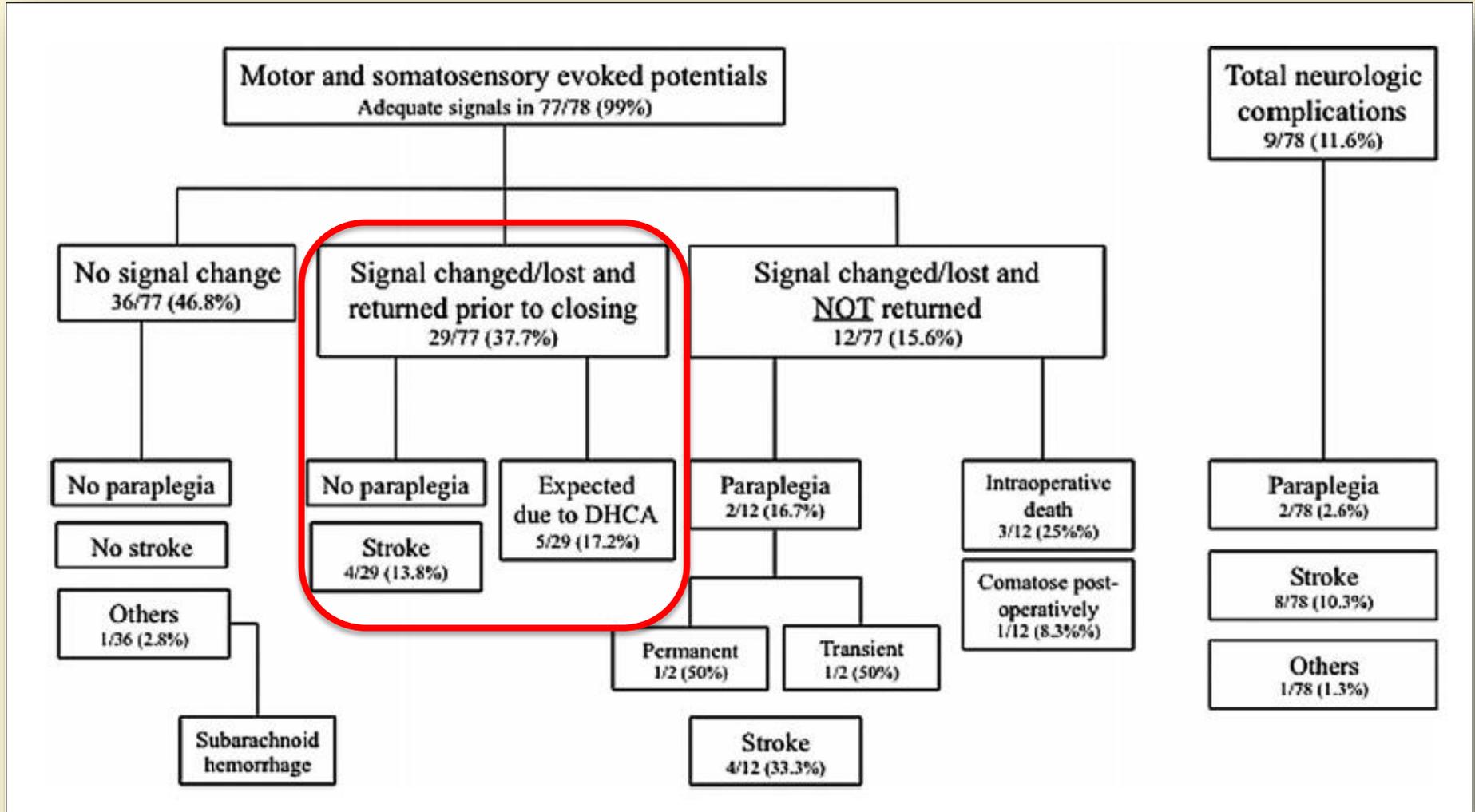
# Surgical Protocol

- Types of Interventions:
  - Open Descending Replacement – 20 (25%)
  - Stage 2 Elephant Trunk procedures – 24 (31%)
  - Open Thoracoabdominal Repair – 29 (37%)
  - TEVAR – 2 (3%)
  - Extra-anatomical Bypass – 3 (4%)
- Bypass used:
  - Left-heart bypass – 61 (78%)
  - Cardiopulmonary bypass – 8 (10%)
    - Deep hypothermic circulatory arrest – 4 (5%)
  - No bypass required – 9 (12%)

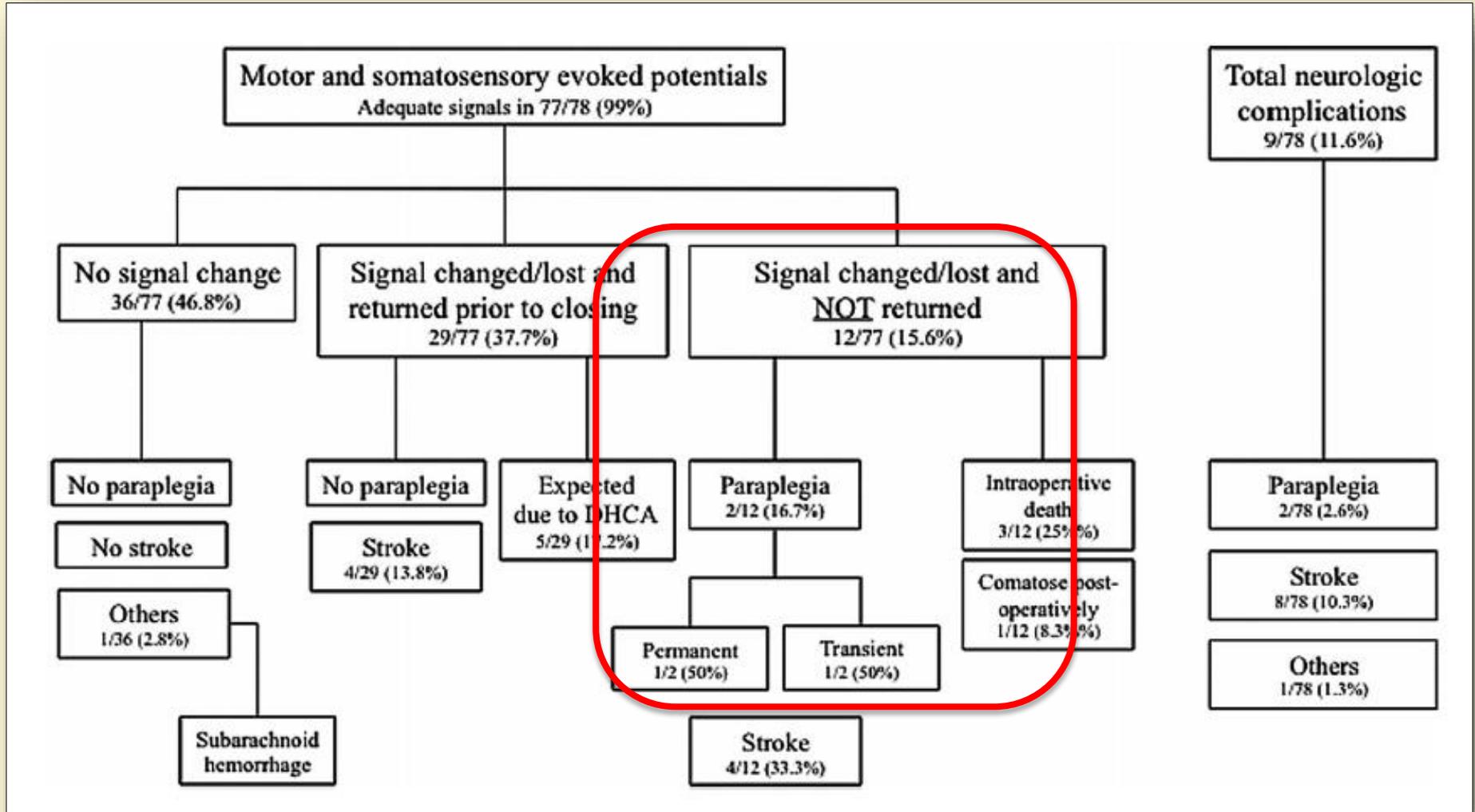
# Patient Outcomes



# Patient Outcomes



# Patient Outcomes



# Specificity and Sensitivity

**TABLE 3**  
**Calculation of Specificity and Sensitivity in Evaluable Patients**

	Signal Loss (Positive)	Signal Return (Negative)	Total
Paraplegia	2 (TP)	0 (FN)	2
No paraplegia	4 (FP)	65 (TN)	69
Total	6	65	71

A total of 77 patients had sufficient signals. Three intraoperative deaths were excluded; three additional comatose patients, in whom neurological exams could not be elicited, were also excluded. This yielded a total of 71 evaluable patients. FN = false negative; FP = false positive; TN = true negative; TP = true positive.

$$\text{Sensitivity} = \text{TP}/(\text{TP} + \text{FN}) = 2/(2 + 0) = 100\%.$$

$$\text{Specificity} = \text{TN}/(\text{TN} + \text{FP}) = 65/(65 + 6) = 94.20\%$$

# Conclusions

- The use of neuromonitoring has become routine at our center.
- We find neuromonitoring helpful in two ways:
  - First, preservation or full return of signals heralds good neurologic outcome allowing the team to “breathe easy,” so to speak, in those cases.
  - Second, failure of spinal return, while usually not followed by paraplegia, encourages us to further optimize cord perfusion (by raising blood pressure, and raising hematocrit and oxygenation).
- Our experience supports the growing popularity of neuromonitoring during descending and thoracoabdominal aortic resection.