Incidence of Complications Using Two Methods of Deep Sedation for Cardiac Magnetic Resonance Imaging (MRI) in Pediatric Patients

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INTRODUCTION

- Children who undergo MRI scanning usually require deep sedation to minimize motion artifacts.
- Propofol, pentobarbital, and other agents are commonly used to induce deep sedation in children for this purpose.

- Propofol's rapid distribution and plasma clearance require either repeated boluses or a continuous infusion to maintain the level of sedation.
- Propofol permits faster onset and recovery to a pentobarbital / midazolam / fentanyl regimen[9].

- Pentobarbital has been shown to be safe and effective when used with midazolam or fentanyl for sedation during pediatric diagnostic imaging[3-4].

- At Oregon Health & Science University (OHSU), children are sedated for diagnostic imaging with intravenous (IV) propofol or IV pentobarbital/propofol (mixed) regimens. In addition, airway devices (LMA or ETT) are very rarely used.

BACKGROUND

- We previously reviewed 7,839 deep sedations for pediatric MRI between 1998 and 2008 from our service and reported a 10.1% incidence of complications, of which 24 (0.003%) were major[11].
- Sedation regimen was found to be a significant predictor of complications: pento mixed regimen was associated with a lower risk of complications than the propofol regimen, and trended toward significant; pento rescue group was associated with a significantly increased risk of complications than the pento mixed group[11].
- In this study we analyze the subgroup of Cardiac MRI patients excluded from the previous study due to their unique physiology.

OBJECTIVE

- To compare of the incidence of complications of a propofol vs. a mixed pentobarbital regimen when used for deep sedation for children undergoing Cardiac MRI.

METHODS

Data Collection and Analysis

- We reviewed records and collected demographic and medical data for 183 children deeply sedated for cardiac MRI between 1998 and 2008.
- We evaluated the incidence and types of complications that were collected prospectively using the Sedation CQI form completed for each patient.
- We identified any predictor variables for complications, and multiple logistic regression analysis was used to investigate whether type of sedation was associated with complications after adjusting for potential confounders. Significance was set as $p = <0.05$.

- Major complications were defined as aborted procedure, aspiration, cardiac arrest, dysrhythmia, hypotension, unplanned admission to ICU or ward, and unplanned intubation.

- Minor complications were defined as airway obstruction, apnea, coughing, desaturation below 92%, drug error, inadequate sedation, IV infiltration, multiple IV sticks (>3 tries), nausea/vomiting, post-study agitation, excessive secretions and unplanned admission to PACU.

Techniques

- For the pento (mixed) group, following midazolam premedication 2-4 mg/kg of pentobarbital was used followed by 0.5-1 mg/kg of propofol.
- For the propofol group, premedication was followed by propofol induction (2-4 mg/kg) and a propofol infusion (125-200 mcg/kg/min).
- For pento (mixed) group patients needing rescue (pento rescue group), due to longer scan duration an additional dose of pentobarbital and/or propofol (due to a ceiling on the total pento dose of 5mg/kg) was used.

RESULTS

Table 1: Demographics

	n	%		
Sex (n=179)				
Male	91	50.8		
Female	88	49.2		
	Mean	**SD**	**Min**	**Max**
Age (yrs) (n=182)				
	5.9	5.0	0	25.7
Weight (kg) (n=182)				
	21.7	15.4	2.7	67.0

Table 2: ASA Class Distribution

Baseline (n=33)	n	%
ASA Classification		
I	0	0
II	10	30.3
III	19	57.9
IV	4	12.1

Table 5: Cardiac Diagnosis

	n
Tetralogy of Fallot	4
Septal Defects	6
Transposition of Great Arteries	3
Total Anomalous Pulmonary Venous Connection	0
Dextrocardia	1
Coarctation of Aorta	5
Other Congenital Heart Disease	11

Table 3: Incidence of Complications

Baseline (n=183)	n	%
Complications*	33	18.0

*Includes 4 cases where patients received the unique method of sedation with a large propofol bolus.

Table 4: Complications

Baseline (n=68)	n	%
Major Complications		
Aborted procedure	2	2.9
Aspiration	0	0
Cardiac arrest	0	0
Dysrhythmia	0	0
Hypotension	1	1.5
Unplanned admission ICU	0	0
Unplanned admission Ward	1	1.5
Unplanned intubation	3	4.4
Minor Complications		
Airway obstruction yes intervention	13	19.1
Apnea no intervention	7	10.3
Apnea yes intervention	7	10.3
Coughing	7	10.3
Desaturation no intervention	2	2.9
Desaturation yes intervention	23	33.8
Drug error	0	0
Inadequate sedation	0	0
IV infiltration	0	0
Multiple IV sticks (>3 tries)	1	1.5
Nausea and/or vomiting	1	1.5
Post-study agitation	0	0
Excessive secretions	6	8.8
Unplanned admission to PACU	1	1.5

MULTIPLE LOGISTIC REGRESSION ANALYSIS (TABLE 6-7)

- After adjusting for ASA physical status, type of sedation was significantly associated with developing any complication ($p<0.0025$); mixed pentobarbital technique (O.R. 0.78, 95% CI 0.66-0.92) vs. the propofol technique.
- Also, if the anesthesiologist delivering care was from the pediatric cardiac subgroup, patients were found to have decreased odds of complications when compared to all the non-cardiac pediatric anesthesiologists as a group.

Table 6: Type of Sedation – Relative Association with Complications

Baseline (n=179)	Odds Ratio	95% Confidence Limits
Pento (Mixed) vs Propofol	0.78	0.66 – 0.92

Table 7: Cardiac Anesthesiologist – Relative Association with Complications

Baseline (n=179)	Odds Ratio	Pr > Z	95% Confidence Limits
Anesthesiologist 1	0.28	<.0001	0.20 – 0.38
Anesthesiologist 2	0.55	<.0001	0.41 – 0.74
Anesthesiologist 3	0.41	<.0001	0.37 – 0.44

Table 8: Airway Interventions

	n
Jaw manipulation	6
Blow by O2	28
Nasal prongs	19
Face mask	0
Bag mask	9
Oral airway	9
Nasal airway	2
Endotracheal Tube	1
Repositioning	1
Suctioning	3
LMA	4
Trach	1

Table 9: Regimen Received

	n	%
Propofol	124	69.3
Pento (Mixed)	55	30.7

Table 10: Bolus Dose

	mg/kg	SD
Propofol	4.6	5.4
Pento (Mixed)	3.4	0.77

Table 11: Procedure & Recovery Times

	n	Min	Max	Mean	SD
Sedation Time	182	8.0	225	116	38.9

DISCUSSION

Study Design and Size

Complications occurred in 33 (18.0%) of 183 deep sedations performed for cardiac MRI, significantly higher than the 10.1% incidence of complications of primarily non-cardiac MRI patients from our earlier study ($p = 0.0005$)[11]. There were 7(3.8%) major complications, significantly higher than non-cardiac MRI patients in our earlier study ($p< 0.001$). A study by Hoffman et al indicated a lower adverse event rate of 9.2% associated with deep sedation (DS), though with a much smaller sample size of only 65[1]. A study by Cravero et al of 30,037 pediatric patients reported a 5.3% incidence of similar complications[2] but included all levels of sedation, such as anxiolysis and minimal sedation, as opposed to DS only, which could explain the difference in incidence. Certainly, our complication rate is higher than in many other studies due to the higher risk population we studied. Many patients had complex intra-cardiac defects, with mixing of oxygenated and deoxygenated blood and limited cardiopulmonary reserve (Table 5). The findings of our study are a substantial addition to the current literature however, the retrospective nature of the study has inherent limitations such as self-report bias, and incomplete documentation.

General Anesthesia (GA) versus DS in Cardiac MRI Patients

Given that DS for cardiac MRI is associated with a higher incidence of complications likely due to cardiovascular compromise, GA is often considered because patients are less accessible during MRI than other imaging environments where DS is often used[12], and GA allows for higher-quality "breath-hold" images possible[13]. However, GA is more invasive than DS. Also, intubation and positive pressure ventilation often used with GA makes physiological and functional measurements of cardiac MRI less reflective of the patient's actual cardiovascular state. A retrospective study of 660 DS and 161 GA patients with congenital heart disease (CHD) undergoing cardiac MRI found that imaging quality was similar using either technique, the adverse event rate was not significantly different (GA 3.9% versus DS 2.8% or 4.8%), and the success rate was not significantly different (DS 97.9% versus GA 100%)[14]. However, the GA group contained more critically ill patients than the DS group. In general, patients with CHD can safely undergo cardiac MRI with DS, but GA should be considered if they have major hemodynamic or respiratory compromise, if more than one procedure is to be performed, or if DS has failed[14].

Pento (mixed) vs Propofol Regimens

The pento (mixed) regimen was associated with a significantly lower risk of complications than the propofol regimen (Table 6). The result was similar in our previous study of non-cardiac patients, which trended toward significant[11]. Short-acting barbiturates have been shown to be safe and effective when used with midazolam or fentanyl for sedation during pediatric diagnostic imaging[3-4]. One study showed that although oral pentobarbital and oral chloral hydrate are equally effective, the incidence of adverse events with pentobarbital was significantly lower in infants younger than 2 years during MRI and CT, including fewer episodes of oxygen desaturation with pentobarbital (0.2%) than with chloral hydrate (1.6%). Use of propofol for sedation has been associated with hypoxia and/or respiratory depression in several studies[5-7].

Implications of Large Propofol Bolus Patients

4 patients with complications received DS from one of the attending anesthesiologists who utilizes a unique method of sedation with propofol (large bolus over 10-15 minutes and no infusion) that may have significantly different physiological effects that would invalidate any comparison with patients sedated with propofol using the 'usual' method. One of these cases was associated with a major complication (aborted procedure) that was, however, a result of inability to get satisfactory images due to the coil in the patient's patent ductus arteriosis. Thus, the aborted procedure likely has minimal implications for the results at large.

CONCLUSIONS AND FUTURE DIRECTIONS

Our study suggests that the pento (mixed) regimen was assocciated with fewer complications than the propofol regimen, and that if the anesthesiologist delivering care was from the pediatric cardiac subgroup, patients were found to have decreased odds of complications. However, further study of whether propofol and/or pentobarbital doses are significant predictor variables for complications might further elucidate the results of this study. In addition, a separate analysis on the incidence of complications in the large propofol bolus group will be necessary in order to further review our institution's sedation practices and institute protocols that have both improved patient outcomes or increase efficiency.

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