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MRI-compatible audio/visual system: impact on pediatric sedation

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Abstract *Background.* While sedation is necessary for much pediatric imaging, there are new alternatives that may help patients hold still without medication.
Objective. We examined the effect of an audio/visual system consisting of video goggles and earphones on the need for sedation during magnetic resonance imaging (MRI).
Materials and methods. All MRI examinations from May 1999 to October 1999 performed after installation of the MRVision 2000 (Resonance Technology, Inc.) were compared to the same 6-month period in 1998. Imaging and sedation protocols remained constant. Data collected included: patient age, type of examination, use of intravenous contrast enhancement, and need for sedation. The average supply charge and nursing cost per sedated patient were calculated.
Results. The 955 patients from 1998 and 1,112 patients from 1999 were similar in demographics and examination distribution. There was an overall reduction in the percent of patients requiring sedation in the group using the video goggle system from 49 to 40% ($P < 0.001$). There was no significant change for 0–2 years ($P = 0.805$), but there was a reduction from 53 to 40% for age 3–10 years ($P < 0.001$) and 16 to 8% for those older than 10 years ($P < 0.001$). There was a 17% decrease in MRI room time for those patients whose examinations could be performed without sedation. Sedation costs per patient were $80 for nursing and $29 for supplies.
Conclusion. The use of this video system reduced the number of children requiring sedation for MRI examination by 18%. In addition to reducing patient risk, this can potentially reduce cost.

Introduction

Patient motion during magnetic resonance imaging (MRI) degrades image quality. Motion is a particular problem in patients that are too young or debilitated to voluntarily hold still for an entire examination. Sedation can be used to decrease patient movement, but sedation carries the small attendant risks of cardiac and respiratory depression. The cost of sedation in time, personnel, and equipment for patient preparation, monitoring, and recovery is substantial. Successful approaches to decreasing the use of sedation include the use of headphones with audio programs and patient preparation using simulation techniques [1–3]. However, sedation is still frequently required for imaging of young children and those with developmental delay or hyperactivity disorders.

The use of video systems during radiation therapy and echocardiography has been shown to decrease the need for sedation in children during these procedures [4, 5]. The use of mirror-reflected video with feedback during simulated MRI in four children reduced head motion to acceptable levels for neuroimaging [6]. The more recent development of MRI compatible devices

Fig. 1 A 3-year-old patient tests the fit of the video goggle system prior to MRI examination

now allows viewing of video during real-time examination. We examined such a video goggle system for its effect on the need for sedation in children undergoing MRI, the impact on examination time and throughput, and the potential cost savings related to the reduction in the need for sedation.

Materials and methods

In May of 1999 the MRVision 2000 (Resonance Technology, Northridge, Calif.) was installed at our institution. The goggles and headphone unit are compatible with the magnets of all manufacturers up to a strength of 4T. The system allows a patient to view a videotape of their choice on a small binocular headset. Noise-reducing earphones deliver the audio signal (Fig. 1). The patients were assessed by a registered nurse dedicated to performing intravenous sedation and monitoring during radiologic procedures. All developmentally normal children and sufficiently cooperative developmentally delayed children able to understand the device were given a trial of the video unit. All other patients and those who continued to move or feel claustrophobic despite the presence of the headset were sedated. Imaging was performed on a 1.5T Visart (Toshiba).

Our radiology information system was searched for all patients who had undergone MRI examination during the first 6 months that the audio/video system was in use. The control group of patients was identified by a similar search for patients who had undergone MRI examination over the same 6-month period 1 year earlier. Data collected from both groups included: patient age, type of examination, use of intravenous contrast enhancement, and need for sedation. The percentage of patients requiring sedation for complete and satisfactory imaging was calculated by patient age and statistical analysis performed using a chi-square test. Variables with potential for affecting sedation use such as imaging protocols, sedation protocols, nursing personnel, attending pediatric radiologists, and hardware upgrades were evaluated.

A prospective workflow analysis of our most frequent examination (non-contrast-enhanced brain MRI) was performed over a 3-month period during use of the video goggles. The time in the MRI examination room was recorded for all patients. Placement of intravenous catheters and subsequent administration of sedative in those patients requiring sedation occurred within this room and is thus reflected by this time measurement. Comparison of average room time for sedated and non-sedated patients was performed.

An estimate of monetary impact was also examined. The direct cost of sedation was determined by addition of nursing costs and direct supply costs per patient. No estimation of cost of physician time was included. Because of the low, inconsistent, and variable rate of reimbursement for sedation, the revenue related to sedation was also not considered.

Results

From 1 May 1998 to 31 October 1998 a total of 955 patients underwent MRI examination. From 1 May 1999 to 31 October 1999 after installation of the video goggles 1,112 patients were imaged. The distribution of MRI examination type (i. e., brain, spine, abdomen, knee, etc.) and use of intravenous contrast enhancement was the same over the two time periods. No significant changes had been made in examination sequence protocols, sedation policies, nursing personnel, or attending physicians. All scans were performed on the same 1.5T system.

The percentage of children requiring sedation in the two groups was plotted against age in years (Fig. 2). In both groups of patients there was a high rate of sedation of children 0–2 years old with a linear decrease in the percent requiring sedation from age 3–10 years and a less dramatic decrease above 10 years. For this reason we performed our statistical analysis on these three age groupings (Table 1). Decrease in the need for sedation was significant in the 3–10 year and greater than 10-year-old groups. Overall there was a decrease in the percent of patients requiring sedation from 469/955 (49 %) to 440/1112 (40 %) with $P < 0.001$.

Over the 3 months from 1 August 1999 to 31 October 1999 there were 191 non-contrast-enhanced MRI exam-

Table 1 Use of sedation by age group

Age range (years)	Before goggles			After goggles			*P*-value
	Patients	Sedated	Percent	Patients	Sedated	Percent	
0–2	249	228	92 %	254	231	91 %	0.805
3–10	352	185	53 %	429	173	40 %	< 0.001
> 10	354	56	16 %	429	36	8 %	< 0.001

Fig. 2 The percentage of patients requiring sedation for MRI examination is plotted against age in years

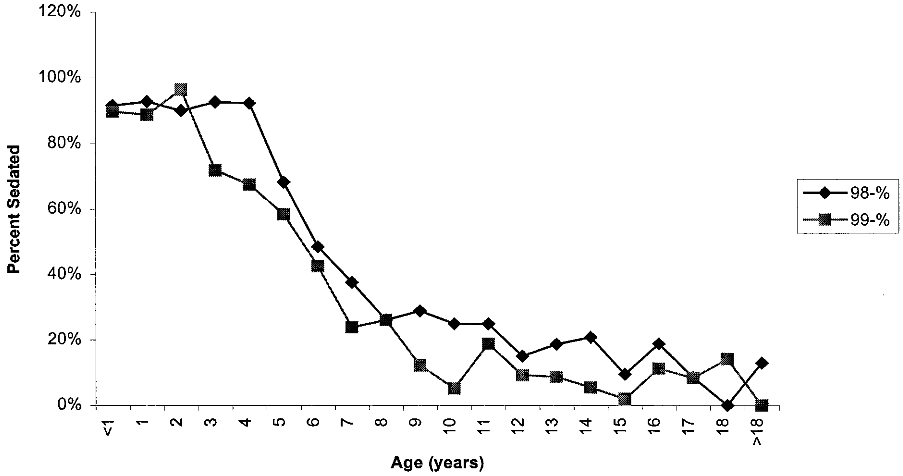

Table 2 Cost per sedation for MRI

Nursing	$ 80.00
Equipment amortization	$ 12.40
Nembutal	$ 1.94
Normal saline flush	$ 0.18
Heplock	$ 0.85
Three 5-cc syringes	$ 0.21
Intravenous needle	$ 0.38
Flush needle	$ 0.03
Basin	$ 0.09
3-way stopcock	$ 0.34
Arm board	$ 3.25
Gloves	$ 0.09
Pulse oximeter probe	$ 8.75
Thermometer cover	$ 0.05
Alcohol wipes	$ 0.03
Cotton balls	$ 0.10
Mountain Dew	$ 0.50
Paperwork forms	$ 0.40
Betadine prep	$ 0.05
Band-aid	$ 0.03
Stickers	$ 0.15
	$ 109.82

inations of the brain completed. Ninety-four examinations were performed with sedation and 97 without. Average room time required for the MRI examination was 42 ± 13 min with sedation and 35 ± 11 min without ($P < 0.0001$).

Nursing salary including benefits was estimated to be $40.00/h. Time involved in preparation, monitoring, recovery, and discharge instruction was estimated at 2 h/examination. Nursing cost plus direct supplies and amortization of necessary monitoring equipment totaled $109.82/examination (Table 2).

The standard price for MRVision 2000 is $35,000 (Mokhtar Ziarati, Resonance Technology, personal communication). The package includes the audio-visual system including microphone for the patient to communicate via intercom. There is an additional $1,000–$2,000 for installation. It comes with a 1-year warranty on parts and labor. From 1 May 1999 to 31 October 2000 (18 months) our unit has required service three times. Total downtime during regular scanning hours was 5 days, as the majority of the repair work was completed over weekend days.

Discussion

The absence of patient motion is necessary for optimal MRI. Historically, sedation has been required in almost 50 % of the pediatric patients that are imaged. We adhere to The American Academy of Pediatrics published guidelines for monitoring and managing sedation in pediatrics [7]. Our regimen for sedation during diagnostic imaging utilizes intravenous pentobarbital sodium (Nembutal, Abbott Laboratories, North Chicago, Ill.), which has been shown to be effective with a very low rate of sedation-related complications [8]. However, the risk of sedation cannot be eliminated. In 1998, our department had ten patients (1 %) experience peripheral oxygen desaturation of > 15 % below baseline; one patient required hospitalization. Nine patients (1 %) experienced an idiopathic hyperactive response to the sedative and required prolonged monitoring. In addition to the issue of patient safety, there is considerable cost of sedation in terms of the personnel necessary for monitoring and the additional time in the imaging department for induction and recovery. These factors have encouraged us to explore any methods of reducing patient motion without the use of pharmacologic assistance.

MRI-compatible audio systems have been available for many years and can help by distracting the patient and masking the gradient noise. Early video systems using a screen mounted within the bore of the magnet or reflected by a mirror to the patient have been tried.

However, these do little to minimize the claustrophobic experience many patients have in the small-bore tunnel of the magnet. The system under evaluation consists of goggles, which completely enclose the eyes. Dual video feeds produce the 3D effect of viewing a 5-foot-wide screen from 10 feet away. Combined with headphones this helps to eliminate both the noise of the gradients and the enclosed feeling of the tunnel.

The hypnotic effect of intravenous Nembutal is rapid. In practice this allows us to attempt the MRI examination without sedation in marginal patients. If a patient fails this attempt, sedation can be administered without seriously delaying subsequent examinations. This same practice allowed us to offer the video goggles first to all children that seemed able to wear them. If the goggles proved ineffective, then sedation was administered. Use of the goggles had no impact on the need for sedation in children under the age of 3 years. We sedated 25 % fewer children age 3–10 years and 50 % fewer children over the age of 10. Overall, we experienced an 18 % decrease in the use of sedation.

We measured a 17 % reduction in MRI room time from 42 to 35 min when sedated patients were compared to non-sedated patients. Recognizing that only a single examination type was used for this comparison, we still found a significant improvement in workflow through our MRI room when examinations could be completed without sedation.

We perform approximately 2,000 MRI examinations/year. Reducing the need for sedation from 49 to 40 % results in 180 fewer patients requiring sedation. At $110 per sedation there is considerable potential for cost savings.

Safe and effective sedation has been achieved through increasingly sophisticated monitoring and familiarity with various methods of sedation. Even so, the use of the MRI-compatible video goggle system has eliminated the need for sedation in a significant number of patients 3 years of age and older, effectively eliminating even the small risk of current sedation protocols for these children. In addition, we have demonstrated the positive impact on workflow and potential for reduction in cost when sedation is not used.

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