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Reducing Anesthesia Use for Pediatric Magnetic Resonance Imaging: The Effects of a Patient- and Family-Centered Intervention on Image Quality, Health-care Costs, and Operational Efficiency

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A B S T R A C T

Children with complex medical problems who require anesthesia are known to be at risk for acute adverse physiologic events related to anesthesia. The risks of anesthesia include short- and long-term psychological and neurobehavioral issues. Magnetic resonance imaging (MRI) has emerged as the standard of care for diagnosis and follow-up of many conditions, and more children are being subjected to anesthesia to ensure acceptable motion-free image quality of the MRI scans. The aim of this study was to evaluate the effectiveness of an anesthesia-free patient- and family-centered intervention through an analysis of MRI quality, health-care costs, and operational efficiency as compared with other approaches. This study retrospectively reviewed patient data extracted from electronic medical records of children aged 3-17 years, who underwent outpatient MRI at an urban academic medical center from 2015 to 2016. A total matched sample size of 500 children, 125 per group, was used to investigate the outcome variables including the quality of magnetic resonance image, health-care cost, and procedural time. The groups included are as follows: (1) intervention group, patient- and family-centered preparation of the child, and no anesthesia given (PFC/NA); (2) comparison group, no structured preparation, and no anesthesia given (SC/NA); (3) comparison group, certified child life specialist preparation, and anesthesia given (CCLS/A); (4) comparison group, no structured preparation, anesthesia given (SC/A). The PFC/NA intervention group was found to have significantly lower costs ($p < .0001$) and shorter procedure times ($p < .0001$), and 96.8% of the MRI images were of acceptable or better quality than those of the SC/A and CCLS/A groups. The PFC approach provides a way for children to undergo outpatient diagnostic MRI without the need for anesthesia, thus reducing risk, costs, and procedure time.

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The challenges of improving the health-care system at all levels have brought about an invigorated focus on patient safety, satisfaction, outcomes, quality of care, reducing waste, and maximizing efficiency (The Patient Protection and Affordable Care Act, 2013). Diagnostic magnetic resonance imaging (MRI) in children often requires some sort of anesthesia, either sedation or general, to ensure satisfactory motion-free quality image acquisition (Uffman et al., 2017). Risks of any form of anesthesia includes acute adverse events, such as respiratory depression, airway obstruction, bronchospasm or laryngospasm, aspiration pneumonitis, cardiovascular depression, arrhythmias, hypotension, untoward reactions to any of the medications used such as anaphylaxis or malignant hyperthermia, emergence delirium, nausea, and vomiting (Kannikeswaran et al., 2009; Sanborn et al., 2005). Preprocedural anxiety, a stressful inhalation induction, and emergence delirium have been linked to new onset of postprocedural maladaptive behaviors such as general anxiety, nighttime crying, enuresis, separation anxiety, and temper tantrums that may continue for days or weeks beyond the anesthesia event (Hilly et al., 2015; Kain et al., 1999; Kain et al., 2004). Children less than 3 years of age who are repeatedly exposed to general anesthesia, as is often the case for children with complex and/or chronic conditions, may be at increased risk for the later development of attention-deficit hyperactivity disorder (Efron et al., 2017; Sprung et al., 2012). Even single exposures have been associated with deficits in some areas of academic achievement (Hu et al., 2017).

Pediatricians and pediatric specialists frequently order diagnostic MRI procedures to be performed with an anesthesiologist present to administer sedation or general anesthesia as needed to ensure motion-free quality imaging and a satisfactory stress-free overall experience for the child and parents. Owing to an estimated increase in the population of children in the United States by 1.4 million in the next 8 years along with the rapid advancements in technology, it is projected that the use of anesthesiology services for MRI in the pediatric population will also increase (Uffman et al., 2017).

Anesthesia for children having a diagnostic MRI is most often completed without untoward events, but the risks remains finite and frequent enough to warrant concern by all involved (Masaracchia et al., 2017). Radiologists, anesthesiologists, and pediatricians are rethinking the routine use of anesthesia services for children, especially those with particularly complex comorbidities (Cravero and Callahan, 2017; Efron et al., 2017; Hilly et al., 2015; Hu et al., 2017; Masaracchia et al., 2017; Sprung et al., 2012). There are concerns regarding the increased time consumed when an anesthesiologist is involved. These concerns range from the need for preprocedural evaluation, induction, emergence, transport to the postanesthesia care unit, and costs such as those of equipment, medications, and staffing of the preanesthesia and postanesthesia care units. There are also challenges of limited availability of pediatric anesthesiology services in some facilities, which has lead to further reassessment of the use of anesthesiology services for MRI in the pediatric population. Computed tomography (CT), as a diagnostic modality, often obviates the need for anesthesia because it is much faster to complete the imaging than MRI, but imaging limitations and exposure to radiation during CT remain a concern.

Patient- and family-centered care (PFCC) has been shown to improve patient and family satisfaction, as well as staff satisfaction in many aspects of patient care (Mastro et al., 2014). PFCC is based on concepts such as sharing power and responsibility, building a relationship of trust between the patient and health-care staff, and engagement of the patient as an active participant in their care management (Hughes, 2011). However, little has been studied about the role PFCC, and this may have an impact on the quality of care, safety, and health-care economics in MRI (Carver and Jessie, 2017).

Different methods have been tried, with varying degrees of success, to reduce the need for anesthesia in children undergoing MRI (Durand et al., 2015; Munn and Jordan, 2013). A patient- and family-centered method designed by nurses at the study site was an opportunity to study its effectiveness in eliminating the necessity for anesthesia while providing a satisfactory motion-free quality scan, reducing costs, and shortening the duration of each procedure.

Ethical approval

This was the evaluation of an existing patient- and family-centered nonanesthesia program, and the existing data were extracted from the electronic health records. The extraction of electronic health record data did not require patients to be recruited to participate in the study, nor were additional consents required. The study protocol was approved by the Colorado Multiple Institutional Review Board and Columbia University Review Board.

Methods

Study Population

A retrospective review of medical records identified 2698 children aged 3-17 years, who underwent an outpatient MRI at an urban academic medical center in New York City from January 2015 through September 2016. A power analysis performed a priori determined that a sample size of 84 encounters (or visits from children) per group was needed (see the Statistical Analysis section for details). As a conservative approach and to account for unforeseen dependencies in the data, 125 encounters per group were selected for analysis in this study. Children in each group were matched based on age, gender, ethnicity, prior MRI experience, and type of body part scanned (see the Statistical Analysis section for details).

Groups and Operational Definitions

The following groups were those considered in this study (Figure 1):

1. Intervention group: patient- and family-centered preparation of the child, no anesthesia given (PFC/NA);
2. Comparison group: standard care, no anesthesia given (SC/NA);
3. Comparison group: certified child life specialist preparation, anesthesia given (CCLS/A); and
4. Comparison group: standard care, anesthesia given (SC/A)

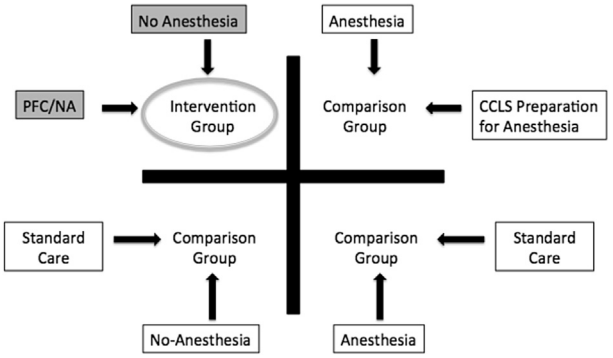

Figure 1. Study groups. CCLS = certified child life specialist; PFC/NA = patient- and family-centered preparation of the child, and no anesthesia given.

Intervention Group (PFC/NA)

The intervention was operationally defined and characterized by three main activities of care: (1) caregiver consultation conducted by a certified child life specialist (CCLS) with the parent (or parent and child) before or on the day of visit to determine their interest in pursuing a nonsedation or general anesthesia alternative, (2) a pre-MRI preparation session for the child, and (3) personalized interventions and support during the MRI procedure. The intervention group did not receive sedation or GA.

In general, the role of a CCLS is to create therapeutic relationships and use knowledge of the child/family to implement care strategies specific to the individual, ultimately maximizing the true potential of the child (Squires & Allen, 2009; Thompson, 2009). During the intervention, a CCLS consults with the parent before the MRI to obtain knowledge of the child's behaviors, fears, difficulties, concerns, and developmental nuances regarding the MRI procedure. In the event of cognitive or behavioral disabilities, the CCLS addressed the individual needs of the child and tailored delivery of the intervention appropriately. Based on parental input about her/his child, the CCLS developed a personalized plan of care to meet the specific needs of the child. If the child was old enough, he/she also participated in the consultation. Questions asked during caregiver consultation before the MRI visit are as follows:

a. Has your child had an MRI before?
   i. Did your child have sedation for the MRI?
   ii. What was that experience like for your child?
b. Is your child fearful of tight spaces?
c. What normally soothes your child when anxious?
d. Does your child have difficulty with loud noises or other sensations?
e. What is your child's primary language?
f. Have you spoken to your child about coming to MRI?

Then, during the pre-MRI preparation session for the child, the CCLS prepared the child, using developmentally appropriate, patient-centered methods. Those methods include a preparation book downloaded onto an iPad, developmentally appropriate medical play session and demonstrations, and practice of developmentally appropriate coping strategies. The pre-MRI preparation session includes the following elements:

g. A preparation book on iPad (with sounds, pictures, and text) introduces the front desk administrative staff; the registration room and application of identification wrist band; the waiting room; the examination room and nursing staff, how vital signs are obtained, and hospital pajamas; the wait-and-play area with child life and play normalization; the preparation room; the MRI room with sounds of the MRI and photos of child receiving an MRI; the technician room with pictures of technicians; and the process of leaving the MRI
h. A medical play session led by the child, allowing the child to express fears, concerns, or comfort level
i. A preparation session with a mock toy MRI scanner with figures and dolls
j. Practice of coping techniques such as keeping still, guided imagery, audio music, and movie with MRI goggles.

Finally, the CCLS and/or parent provides intervention and support during the actual MRI, which is operationalized as coaching by the CCLS, parental presence, and/or MRI movie goggles or music.

Standard Care (SC/NA and SC/A)

A standard care was operationally defined in this study as two instances. In the first, families chose not to have their child receive sedation or GA, and the CCLS was not available to deliver the intervention. The second instance is that families chose for their child to have sedation or GA for the MRI, and the CCLS was not available for preparation for sedation or GA. The standard care for nonsedation or GA and sedation or GA does not include any aspect of the intervention as described.

CCLS Preparation for Sedation or GA (CCLS/A)

CCLS preparation for sedation or GA was operationally defined in this study as those instances in which families chose sedation or GA for their children, and a CCLS prepares them for sedation or GA to reduce the risk of anxiety and distress before sedation or GA. When the CCLS prepares a child, he/she initially assesses their level of knowledge about sedation or GA and MRI, as well as their levels of anxiety and distress. The CCLS then prepares the child by sharing with them a facemask similar to those used for oxygen delivery or for delivery of inhaled anesthesia. The CCLS shows the child a picture of all the people the child would meet before receiving sedation or GA so as to familiarize the child with the anesthesiologist, nurse, and MRI technician.

Use of Sedation or GA

Sedation or GA was operationally defined as receipt of a pharmacological agent for the purpose of sedating or anesthetizing the child during MRI. Alternatively, nonsedation or GA use was operationally defined as nonreceipt of any pharmacological agent for the purpose of sedating or anesthetizing the child during MRI. These data were obtained from the hospital health information record. These data were displayed as dichotomous variables indicating the use or nonuse of sedation or GA.

Outcomes

Magnetic Resonance Image Quality

Image quality was operationally defined as a score on a 5-point Likert-type rating scale measuring the quality of the magnetic resonance image and the level of motion artifact of the image. For all patients receiving an MRI during the study period, the actual magnetic resonance image was reviewed from the picture archiving computer system and graded on the 5-point Likert-type rating scale by an experienced radiologist. Numeric scores on the rating scale corresponded with the following values: 1—excellent quality and no motion artifact; 2—good quality and little motion artifact; 3—acceptable quality and moderate motion artifact; 4—poor quality and excessive motion artifact; 5—child was unable to complete the magnetic resonance imaging.

Hospital Costs

For the purpose of this study, hospital costs were operationally defined as hospital charges. For all patients receiving an MRI during the study period, data were extracted from the hospital cost-accounting system. Total charge was displayed as a continuous variable in dollars and consisted of two subcharges: medication charge and facility charge. The total charge was defined as the cumulative charge released either to the insurance company or to the patient directly should they not have insurance coverage.

Procedural Time

For all patients receiving an MRI during the study period, procedural time was operationally defined as the “in-MRI time.” The in-MRI time included the total procedural time from when the patient entered the MRI room to when the patient exited the MRI room. Because anesthesia begins and ends while the child is in the MRI room, the in-MRI time included the initiation of pharmacologic medications, when used. The in-MRI time variable was displayed in

minutes and was extracted from two existing health information systems: ImageCast and CompuRecord. Both date and time variables were extracted.

Statistical Analysis

Power Analysis

A power analysis for multiple regression was performed a priori to determine sample size. A multiple regression analysis was estimated to evaluate the effect of PFC/NA intervention, age, MRI body area scanned, and prior patient experience on the quality of magnetic resonance image, hospital cost, and procedure time. The power analysis was based on four predictor variables (PFC/NA intervention, age, body area of scan, prior experience), an anticipated moderate effect size of $R^2 = 0.15$, desired statistical power of 0.8, and probability of $\alpha = 0.05$, which indicated that a sample size of 84 encounters per group was needed. As a conservative approach and to account for unforeseen dependencies in the data, 125 encounters per group were chosen, resulting in a final sample size of 500 encounters.

Matching

In the retrospective chart review, data were pulled on all children aged 3-17 years, who underwent an outpatient MRI at an urban academic medical center in New York City from January 2015 through September 2016 to obtain enough children in the intervention group (N = 125). However, this chart review resulted in considerably imbalanced sample sizes and patient characteristics between groups; thus, random sampling was not used. Rather, the encounters were selected or matched to the intervention group, such that each group had similar characteristics, to remove potential analysis issues related to confounding. Nearest-neighbor matching, with logistic regression distance, was performed using the "MatchIt" R package v3.0.1. to create equal-size, covariate-balanced between groups, according to age, gender, ethnicity, prior MRI experience, and type of body part scanned.

Demographics

Descriptive statistics (mean and standard deviation for continuous variables, frequency tables for categorical variables) were calculated on the patient encounter level of data. However, MRI quality was assessed per scan; if there were multiple scans per encounter, the MRI quality was summarized by the median image quality over all scans so that image quality could also be assessed on the encounter level. Group differences in age were analyzed using an analysis of variance; group differences for categorical variables (gender, ethnicity, diagnosis, prior MRI experience, and body area of scan) were analyzed using chi-squared tests.

Quality of MRI

The quality of MRI was a five-point Likert scale variable, with higher values indicating higher quality of scans. The same board-certified radiologist reviewed, graded for quality, and coded the magnetic resonance images that were among the outcome variables of this study. He was blinded as to which group the scans were from, previous readings of the scans by other radiologists, and any background information about any patient. To determine whether there were differences in the quality of MRI scans between the anesthesia and treatment groups, a linear mixed-effects model with a random intercept for a patient was used, adjusted for the matching variables.

Procedural Time

Procedure time difference was a continuous variable, with negative values indicative of a procedure taking longer than expected. To determine whether there were differences in the procedure time between the anesthesia and treatment groups, a linear mixed-effects model with a random intercept for patient was used, adjusted for the matching variables.

Hospital Costs

Hospital cost, which measured charges associated with the postanesthesia care unit and/or medication and supplies related to anesthesia, was a zero-inflated, right-skewed, count variable. To determine whether there were differences in the hospital cost between the anesthesia and treatment groups, a negative binomial mixed-effects model with a random intercept for patient was used, adjusted for the matching variables.

Assumptions and Interpretation

All models were assessed for internal validity and goodness of fit by checking model assumptions. Residual normality and homogeneity of variance were assessed via histograms and quantile-quantile plots. The random intercept for patient in the models accounted for the dependency in the data. Results were considered significant at a level of alpha = 0.05. RStudio® (Boston, MA) v1.0.136 was used for all analyses.

Results

Demographics

After matching, there were 500 unique encounters, split evenly between the PFC/NA intervention, SC/NA, CCLS/A, and SC/A groups. Between groups, there were no significant differences in gender ($p = .605$), ethnicity ($p = .870$), diagnosis ($p = .211$), prior experience ($p = .142$), or body area of scan ($p = .190$). Even after matching, there remained a difference in age between groups ($p < .001$) and a slight difference in the number of scans per encounter ($p = .036$) (Table 1).

Quality of MRI Images

There was no statistically significant difference found in the quality of MRI images between children in the PFC/NA intervention group versus the SC/NA group ($p = .484$). The quality of MRI scans in both the anesthesia groups (CCLS/A and SC/A) was statistically significantly better than the quality of the scans in the PFC/NA intervention group ($p < .001$ for both) (Table 2). However, 96.8% of scans in the PFC/NA group were of acceptable quality or better, with only three patients having unacceptable MRI image quality and one patient unable to complete the scan. In addition, age and body area were both significantly related to the quality of scan. For each year of age, the score for quality of scan increased by 0.021 units (95% confidence interval [CI]: 0.004 to 0.038; $p = .014$), indicating that the quality of scans was better in older children. In addition, scans of the thorax had a 0.488-unit (95% CI: 0.368 to 0.609, p: < .001) worse image quality score than scans of the head (Table 2).

Procedure Time

There was no statistically significant difference found in the procedure time between children in the PFC/NA intervention and those in the SC/NA groups ($p = .593$). However, the procedure time in both the anesthesia groups (CCLS/A and SC/A) was statistically significantly higher than that in the PFC/NA group ($p < .001$ for both); on average, children in the CCLS/A group had 23.61 minutes (95% CI: 13.67 to 33.53 minutes) higher procedure time, and children in the SC/A group had 35.81 minutes (95% CI: 26.06 to 45.50 minutes) higher procedure time than that of children in the

Table 1
Children characteristics

Study variable	PFCC/NA[1] (N = 125)	SC/NA[2] (N = 125)	SC/A[3] (N = 125)	CCLS/A[4] (N = 125)	p Value
Male[5]	68 (54.4)	71 (56.8)	66 (52.8)	76 (60.8)	.605
Age in years, mean (SD)	9.92 (3.57)	9.91 (3.34)	10.29 (3.72)	8.18 (3.40)	**<.001**
Ethnicity					.870
Black	12 (9.6)	10 (8.0)	7 (5.6)	11 (8.8)	
Caucasian	31 (24.8)	31 (24.8)	27 (21.6)	35 (28.0)	
Hispanic	9 (7.2)	10 (8.0)	9 (7.2)	12 (9.6)	
Other or missing	73 (58.4)	74 (59.2)	82 (65.6)	67 (53.6)	
Diagnosis					.211
Autistic disorder	0 (0.0)	0 (0.0)	1 (0.8)	0 (0.0)	
Epilepsy	1 (0.8)	1 (0.8)	4 (3.2)	3 (2.4)	
Other	120 (96.0)	123 (98.4)	120 (96.0)	121 (96.8)	
Sickle cell	4 (3.2)	1 (0.8)	0 (0.0)	1 (0.8)	
Prior MRI experience	38 (30.4)	39 (31.2)	30 (24.0)	47 (37.6)	.142
Thorax scanned (else head)	67 (53.6)	66 (52.8)	65 (52.0)	52 (41.6)	.190
Number of scans per encounter, mean (SD)	1.54 (0.88)	1.31 (0.60)	1.59 (1.11)	1.62 (1.05)	**.036**
Scan quality, mean (SD)	3.66 (0.73)	3.62 (0.79)	4.08 (0.60)	4.12 (0.62)	NA
Time in MRI, difference (expected-observed), mean (SD)	−15.08 (42.25)	−20.69 (40.33)	−48.82 (47.91)	−39.42 (36.67)	NA
Hospital cost, mean (SD)	158.38 (876.99)	16.39 (183.27)	2174.52 (1457.91)	1892.01 (1474.66)	NA

Bolded values indicates statistical significance.
PFCC = patient- and family-centered care; CCLS = certified child life specialist; MRI = magnetic resonance imaging.
[1] PFCC preparation, no anesthesia.
[2] Standard care, no anesthesia.
[3] Standard care, anesthesia.
[4] CCLS, anesthesia.
[5] Values are presented as n (%).

PFC/NA group (Table 3). In addition, prior experience and number of scans per encounter were statistically significantly related to the procedure time. Children with some prior experience had 17.63 minutes (95% CI: 10.09 to 25.20 minutes) longer procedure times than children with no prior experience ($p < .001$). For each additional scan, the procedure time decreases by 13.76 minutes (95% CI: 9.85 to 17.70; $p < .001$) (Table 3).

Hospital Costs

Hospital costs were significantly different between the PFC/NA intervention group and all other groups ($p < .001$ for all). As compared with the PFC/NA intervention group, on average, the incidence rate for hospital costs is higher by a factor of 28.93 (95% CI: 13.73 to 61.49) in the SC/A group, 23.83 (95% CI: 11.55 to 49.50) in the CCLS/A group, and 0.16 (95% CI: 0.06 to 0.37) in the SC/NA group. That is, hospital costs are higher in the SC/A and CCLS/A groups but lower in the SC/NA group than those in the PFC/NA group. Furthermore, for each additional scan per encounter, the incidence rate for hospital costs increases by a factor of 3.02 (95% CI: 2.05 to 4.75) (Table 4).

Discussion

The primary rationale for the use of anesthesia in MRI is to ensure that the child remains still for the duration of time while the scan is being conducted so that the magnetic resonance image quality is acceptable and interpretable. However, the use of anesthesia is not benign and has real physiological and biological side effects for children. Of growing concern is the emerging literature exploring the effects of anesthesia on the developing brain. The concern over these safety risks provides support to explore alternative options to anesthesia for outpatient MRI for children. Although there are many strategies being explored to lessen the side effects of anesthetic drug used for children undergoing MRI, the risks associated with anesthesia remain.

The purpose of this study was to determine if preparation of the child for MRI using a patient- and family-centered methodology

Table 2
Effect of covariates on the quality of MRI

Study variable	Estimate	95% Confidence interval	p Value
SC/NA[2] versus PFCC/NA[1]	−0.058	−0.218, 0.103	.484
SC/A[3] versus PFCC/NA	0.374	0.213, 0.536	**<.001**
CCLS/A[4] versus PFCC/NA	0.435	0.270, 0.601	**<.001**
Age (years)	0.021	0.004, 0.038	**.014**
Male versus female	−0.074	−0.191, 0.042	.216
Prior experience (none vs. any)	−0.064	−0.189, 0.061	.319
Thorax versus head	−0.488	−0.609, −0.368	**<.001**
Number of scans per encounter	0.000	−0.064, 0.065	.998

PFCC = patient- and family-centered care; CCLS = certified child life specialist; MRI = magnetic resonance imaging.
Bolded values indicates statistical significance.
Positive values indicate better quality scans for the first group listed than for the second group, holding all other variables constant. Estimates are from a multivariable linear mixed-effects model.
[1] PFCC preparation, no anesthesia.
[2] Standard care, no anesthesia.
[3] Standard care, anesthesia.
[4] CCLS, anesthesia.

Table 3
Effect of covariates on procedure time

Study variable	Estimate	95% Confidence interval	p Value
SC/NA[2] versus PFCC/NA[1]	−2.672	−12.378, 7.080	.593
SC/A[3] versus PFCC/NA	−35.809	−45.505, −26.056	**<.001**
CCLS/A[4] versus PFCC/NA	−23.613	−33.534, −13.669	**<.001**
Age (years)	0.114	−0.885, 1.109	.823
Male versus female	2.368	−4.590, 9.336	.508
Prior experience (none vs. any)	−17.542	−25.111, −10.004	**<.001**
Thorax versus head	7.183	−0.020, 14.416	.053
Number of scans per encounter	13.784	9.870, 17.716	**<.001**

PFCC = patient- and family-centered care; CCLS = certified child life specialist.
Bolded values indicates statistical significance.
Positive values indicate a longer procedural time for the first group listed than for the second group, holding all other variables constant. Estimates are from a multivariable linear mixed-effects model.
[1] PFCC preparation, no anesthesia.
[2] Standard care, no anesthesia.
[3] Standard care, anesthesia.
[4] CCLS, anesthesia.

Table 4
Effect of covariates on hospital cost

Study variable	IRR	95% Confidence interval	p value
SC/NA[2] versus PFCC/NA[1]	0.155	0.065, 0.367	**<.001**
SC/A[3] versus PFCC/NA	28.932	13.732, 61.492	**<.001**
CCLS/A[4] versus PFCC/NA	23.830	11.554, 49.496	**<.001**
Thorax versus head	0.748	0.394, 1.444	.241
Number of scans per encounter	3.017	2.045, 4.751	**<.001**

PFCC = patient- and family-centered care; CCLS = certified child life specialist; IRR = incidence rate ratio.
Bolded values indicates statistical significance.
Values above 1 indicate a higher incidence rate of hospital costs for the first group listed than that for the second group, holding all other variables constant. Estimates are from a multivariable linear mixed-effects model.
[1] PFCC preparation, no anesthesia.
[2] Standard care, no anesthesia.
[3] Standard care, anesthesia.
[4] CCLS, anesthesia.

reduced the need for anesthesia through evaluating magnetic resonance image quality, procedure times, and health-care costs. The findings of this study support that using a patient- and family-centered approach and partnering with patients and families to prepare children for MRI can lead to reduction of the use of anesthesia in children and provide a viable alternative to promoting safer, timelier, and more cost-effective option than anesthesia.

All hypotheses tested in this study compared the outcome variables such as the quality of magnetic resonance image, health-care cost, and procedure times between the PFC/NA intervention group and three different comparison groups.

The PFC/NA intervention used a structured methodology to create an individualized patient-centered plan to prepare the child for MRI. This methodology drew upon the personal knowledge of the child/family for the development of a personalized preparation plan to maximize the true potential of the child in successfully completing the MRI without anesthesia. Individualized preparation and support during the MRI led to successful completion of the MRI with 96.8% of the magnetic resonance images being acceptable or of better quality and deemed interpretable by the radiologist. Although it was found that, statistically, patients who are sedated have a better quality of scan image, the PFC/NP intervention remains a viable option to sedation.

In addition, the PFC/NA intervention group was found to have significantly lower costs and shorter procedure times than both groups in which anesthesia was given, dispelling the notion that it takes longer for an MRI to be completed when a patient is not under anesthesia. Importantly, the PFC/NA group was not found to have statistically significant differences in image quality, costs, or procedure times compared with the SC/NA group. This suggests that there is a subset of patients in which the PFC/NA approach was advantageous over the anesthesia approaches, and this further supports the intervention as another viable method in eliminating the potential risks associated with anesthesia.

An additional analysis revealed that female patients, patients with prior MRI experience, older children, and those who underwent lower extremity scans had a higher probability of completing the scan without anesthesia and with a satisfactory quality image. These results suggest that patients with this demographic may be ideal candidates for the PFC/NA method of preparation so as to avoid unnecessary anesthesia.

Whether the PFC approach can be modified to expand other demographics and to develop the ability of children to remain motionless during the scan remains to be investigated. Furthermore, effects of the PFC/NA method on such factors as patient and family satisfaction, anxiety or distress, and other short- and long-term psychological and neurobehavioral effects were not explored. The rate of PFC/NA and CCLS/A interventions was limited by availability of CCLS personnel. Nevertheless, of the 3250 total patient encounters, 2243 (69.0%) opted not to receive anesthesia.

Study Limitations

This study was not randomized or prospective; therefore, the internal validity of the analysis may be threatened by other pre-existing factors and influences. However, to prevent some confounding factors, the subjects in each group were selected to obtain similar children characteristics between groups. The rate of PFC/NA and CCLS/A interventions was limited by availability of CCLS personnel. External validity for this study is limited to facilities of similar size, population, and demographics.

Conclusion

A shift from anesthesia as the default method for having patients remain as motionless as possible during their diagnostic study to a nonpharmacologic approach such as the PFC/NA program to minimize risk, shorten procedure time, and reduce costs is underway, with the role of nurses and CCLSs being essential for innovating and enacting such methods. The findings from this study have provided the first evidence that supports a safer, more cost-effective, and more efficient alternative to anesthesia use in children needing a diagnostic MRI. The results of this research reveal that taking a patient- and family-centered approach to care reduces the need for anesthesia in children needing outpatient MRI, thus improving the safety of care for this population. Although additional research is needed to further support these findings and broader application of PFCC practices, the findings of this study help to create an informed design of strategies for improving PFCC practices that focus on improving safety, reducing health-care cost, and improving health-care system efficiencies.

Policy and Practice Implications

Findings of this study help to inform policy and practice guidelines regarding best and safest practices for preparation and conduction of pediatric MRI. The patient- and family-centered intervention has shown that children have the ability to successfully complete an MRI without anesthesia. More importantly, the quality of an overwhelming number of the magnetic resonance images for those children who received the intervention was found to be acceptable to excellent. Implementation of the intervention suggests that the patient- and family-centered preparation method is an acceptable option for parents, radiologists, and other providers when determining the safest, most cost-effective, and most efficient method in obtaining an MRI. As such, it is suggested that the patient- and family-centered intervention used in this study should be considered as an option in practice.

The historical reason for the practice of using anesthesia was to ensure the child remained still to obtain a magnetic resonance image with high enough quality for interpretation. However, the results of this study bring this standard practice under scrutiny. This study supports the proposition that health-care providers should no longer assume children need anesthesia to remain still enough to obtain an acceptable quality magnetic resonance image. In addition, policy-related practice guidelines should reflect a patient- and family-centered approach to individualized preparation and support for children needing MRI so as to avoid anesthesia and promote the safest, timeliest, and most cost-effective care practices.

Implications for Further Nursing Research

This study exemplifies nursing's important role in design, implementation, and evaluation of PFCC practices. This study also begins to fill a gap in the literature and adds to the growing body of patient- and family-centered research. However, replication of this study and the effects of the patient- and family-centered intervention in different health-care settings throughout the United States should be explored, particularly in a prospective randomized trial.

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