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ORIGINAL ARTICLE

Easing anxiety in preparation for pediatric magnetic resonance imaging: a pilot study using animal-assisted therapy

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Abstract

Background Children undergoing magnetic resonance imaging (MRI) can experience negative emotions both before and during their scan, causing them to move and often necessitating the use of procedural sedation. Several strategies to improve patient compliance have been attempted.

Objective This study was designed to evaluate the effectiveness of a non-pharmacological intervention to reduce anxiety in pediatric patients preparing for MRI using animal-assisted therapy.

Materials and methods An animal intervention pilot study was performed in patients who agreed in advance to interact with a dog. Patients and caregivers filled out questionnaires, including questions designed to capture changes in patient emotion before and after the intervention. MRI diagnostic quality was compared to age- and gender-matched control groups with and without general anesthesia.

Results The intervention in 21 patients comparing pre- and post-scan surveys demonstrated a statistically significant improvement in patient anxiety levels ($P<0.01$). Diagnostic MRI scans were achieved in 19/21 (90%), with no significant difference in exam quality or times compared against control groups. The majority of caregivers and staff members agreed strongly that patients benefited from the therapy dog's presence.

Conclusion The use of animal-assisted therapy in a pilot group in our MRI division resulted in a beneficial effect on patients' emotional status, easing anxiety in preparation for scheduled scans, without impacting MRI quality or duration. Further randomized studies will be needed to demonstrate its significance in reducing sedation rates in children undergoing MRI.

Keywords Animal-assisted therapy · Magnetic resonance imaging · Pediatric · Sedation alternatives

Introduction

Achieving diagnostic quality scans in the pediatric population is a daily challenge. Several factors related to magnetic resonance imaging (MRI) can cause fear, agitation and anxiety in patients undergoing MRI including an unfamiliar environment, the presence of unknown staff and lengthy scan times. Children are especially prone to these emotions making it difficult for them to remain still in the scanner, with image quality compromised as a result [1]. Sedation is frequently used in an attempt to help children keep still and improve image quality. This can range from mild to deep sedation or general anesthesia, depending on the patient's level of responsiveness and the need for ventilatory support [2, 3]. However, although using sedation can improve image quality, it's not without risk to the patient even when

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delivered by experienced providers, also considerably impacting workflow and costs [4–7]. Recent research suggests visit times for children having MRI under general anesthesia and/or deep sedation are approximately twice that of awake patients, and affiliated cost estimates have ranged from increases of 2 to more than 9 times [4, 7]. As Robertson et al. [5] identified, novel approaches are needed in pediatrics to ensure high-quality MRI studies are efficient, cost effective, acceptable and of low risk.

In our institution, typically 25% to 30% of patients undergoing MRI require some form of sedation, similar to other tertiary pediatric centers [4]. All deep sedation/general anesthesia at our center is anesthetist-administered, the general anesthetic propofol being the drug of choice in 90% of the cases due to its short action and safety profile. A small dose of anxyolitic (Lorazepam [Ativan]; Pfizer Canada ULC, Kirkland, QC, Canada) is offered to the remainder ("mild sedation"). "Moderate" sedation is not offered. In 2017, this resulted in significantly longer wait times, on average 7 weeks for patients needing deep sedation/general anesthesia versus 2 weeks for awake patients.

In light of this, a variety of strategies are available to increase the likelihood of successfully completing MRI in infants and children without using deep sedation/general anesthesia: optimization of the MRI environment, "feed and sleep" techniques, use of a mock or simulator MRI, MRI-compatible goggles and other audiovisual systems, breathing exercises, therapeutic medical play and guided imagery [8–15]. Among these, mock MRI, certified child-life specialist consultation and the use of audiovisual devices have the most supporting research, especially among 3- to 10-year-old children [16]. In our center, the "feed and sleep" technique is used in patients younger than 6 months old, and in older children we offer goggles to watch movies and/or listen to music as the goggles are used in conjunction with MRI-compatible headphones, with access to a scale mock MRI in a waiting area and educational videos.

To provide an additional tool to optimize the patient experience and alleviate anxiety, while also potentially reducing need for deep sedation/general anesthesia given concerns regarding neurocognitive development in young children as per the 2016 Food and Drug Administration (FDA) warning [17], a preexisting animal-assisted therapy program available in the clinical arena at our institution was expanded to MRI. This intervention was planned to work in conjunction with existing strategies. Animal-assisted therapy is considered a complementary medicine intervention, defined by Halm [18] as "a facilitated interaction between patients and trained animals (as therapist) accompanied by human owners or handlers." With Class IIa-IIb levels of evidence, therapeutic benefits of this intervention have been reported to include reduced symptoms of stress, agitation, depression, pain and related symptoms, with recognition across a range of health care settings [18–22]. Given the paucity of data published to date on the utility of animal-assisted therapy in diagnostic imaging, this study was designed to evaluate effectiveness of this non-pharmacological intervention in reducing anxiety in pediatric patients preparing for MRI, while still achieving diagnostic quality scans [23–30].

Materials and methods

This prospective study was approved as a Quality Improvement Project by the institutional Quality Management Department, to be implemented in a small group of outpatients at a single tertiary pediatric hospital as a 12-month pilot study. Additionally, although the animal-assisted therapy program has been employed in our institution through the volunteer resources program for more than 20 years, implementation in the MRI division required approval from the Infection Prevention and Control Program, ensuring compliance with the Animal and Pets Policy to prevent the transmission and acquisition of infection. This included permission for our therapy dog to be present during insertion of intravenous cannulae (IV) in the MRI preparation area [30].

Project team

The multidisciplinary team led by the project director (a fellowship-trained pediatric radiologist) included the MRI manager, a pediatric registered nurse based in MRI (MRI RN) whose role is to assess patients before scheduling of general anesthesia in MRI, MRI booking clerks and receptionists, pediatric radiology fellows, a clinical research assistant (Ph.D. trained), several MRI technologists and, of course, our therapy dog and her handler. Only one dog was utilized in the pilot project, a 10-year-old female Labrador retriever with 3 years of experience as an accredited therapy dog, including more than 1 year in pediatrics. Her handler is a former Cardiac Intensive Care nurse with a bachelor of education who specialized in pediatrics for more than 20 years. The animal was screened for MRI safety and potential implants by our MRI Safety Office, with her microchip implant determined to be MRI conditional, which meant she was safe to enter even the 3-T scan room [31]. The decision not to keep her in the room during the MRI was due to the risks posed by the noise exposure of the MRI, frequently in excess of 110 dB. Care was also taken with patient selection to best ensure that the dog could not contract methicillin-resistant *Staphylococcus aureus* (MRSA) or become a vector for infection.

Cohort recruitment

The patients were selected from the pediatric outpatients who were referred to our institution for MRI between May 2016 and May 2017. The inclusion criteria were: 1) first attempt at MRI without general anesthesia, 2) chronological/

developmental age older than 4 years, 3) 1 or maximum 2 body regions under examination, and 4) estimated duration of the examination less than 60 min. As our routine age of sedation is up to 6 years old, we were trying to capture the impact on the group with borderline needs. Exclusion criteria included inpatients, emergency cases or multisite MRI. We anticipated patients with dog aversion or allergies would have declined to participate, as the consent/assent was obtained in advance of the hospital visit.

Pre-procedural assessment of patients being considered for MRI under general anesthesia was performed by the MRI RN who identified patients meeting the project inclusion criteria 1–4. This was determined by the referring doctor or caregiver indicating "Unsure" or "No" when asked on the requisition form if the patient would be able to remain still for about 60 min, or because of a history of failed MRI attempts without sedation. Potential candidates were then contacted by phone by the MRI RN or MRI scheduler and parents/caregivers were asked if they were willing to try a non-sedated approach for the MRI that included interaction with our therapy dog and her handler. All parents/caregivers as well as the competent patients gave written informed consent. Subjects too young to provide consent gave assent to the study procedures, the choice of subject consent versus assent left to the discretion of the parent/caregivers. A confirmatory call done by the radiology fellow 2 to 3 days before the arranged date served to explain the process more thoroughly and answer any questions, as well as to set realistic expectations and goals in terms of what could be achieved.

Questionnaires

Several questionnaires were designed to ascertain the participants' anticipated levels of MRI-related anxiety before and after interacting with the therapy dog and to determine their opinions about the experience (Supplementary Material, Appendixes A and B). The project team designed these surveys with guidance from a quality analyst from the institutional Quality Management Department. These included questions on patients' emotional status, as well as their general expectations about the exam and their baseline attitude toward pets. The responses to the anxiety-measuring questions were formatted using a modified visual pictorial analog version for the children, which has already been proven to correlate strongly with more time-consuming multidomain scales such as the preoperative system developed by Kain et al. [32, 33]. Scores were assigned using a 5-point Likert scale, with 0 being the best answer and 4 the worst (Fig. 1).

Intervention

Upon arriving at the MRI department and after completing the standard registration and MRI screening process, the patient and his/her parents/caregivers would meet the research assistant in reception, obtain informed consent, and ask them to complete a pre-MRI survey. After the surveys were completed, the therapy dog and handler would meet the patient and guardian in the MRI department waiting room. Before the intervention, the handler would ascertain if other patients/families in the waiting room were averse to dogs and, if so, the interaction would be relocated to a smaller waiting area.

The interaction included sitting near the dog, petting it and engaging in low-level play under the supervision of the professional trainer, who attended to the dog's needs, answered questions and engaged the family in conversation. The handler also used the dog to reassure children about the upcoming scan – such as placing a pair of "mutt muffs" (headphones designed to protect the hearing of dogs in small aircraft) on the dog as a way of explaining to the patient that they would be wearing earplugs. The dog, who was kept on a loose leash at all times, not only interacted with the patient and the rest of the people in the waiting room but also accompanied the patient into the MRI preparation area (including IV placement if necessary), and finally escorted him/her into the scan room during patient positioning on the MRI table (Fig. 2). Once the patient was positioned in the scanner, the therapy dog would wait in the MRI control room during the scan, occasionally reentering the scan room between sequences if the technologist felt it might help calm the patient. At all times during the interaction, the handler encouraged the child to hold the dog's leash. The patients spent between 20 and 60 min with the therapy dog before the scan, with interaction time during and after the scan more variable based on scan length.

MRI scans

MRI studies were performed on closed bore scanners (1.5- or 3-T Philips Achieva; Philips, Eindhoven, The Netherlands, or 1.5-T GE Twin Speed HDXT 16.2; General Electric, Milwaukee, WI). MRI techniques and parameters varied according to the type of scan. After the examination was complete, the child would meet the animal in the control room and the patient and his/her parents or caregivers would fill out post-intervention surveys indicating the emotional status of the patient according to the same scale as the pre-intervention surveys. The staff member most directly involved with the study, usually the MR technologist, also completed a brief subjective questionnaire about the dog's usefulness.

Data collection

A researcher – either a clinical research assistant (18 out of 21 cases) or a pediatric radiology fellow – administered the questionnaires, usually in the waiting area (or side room if there was anyone averse to dogs in the waiting area). Their role was only to administer the questions, reading them aloud and assisting participants with comprehension. Participants rated

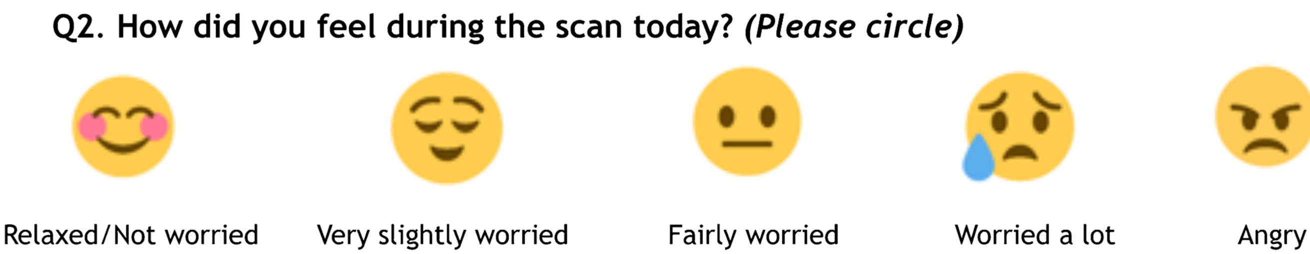

Fig. 1 Visual analogue scale used in both pre- and post-survey questions relating to patient anxiety levels

their own anxiety independently, filling in the surveys themselves if they were old enough to do so. To avoid influencing the ratings, attention was given to ask the questions in the most neutral way possible, always before handing the parents/caregivers the questionnaire, which was filled out by them and then collected.

The MR images were subsequently evaluated by two reviewers, a pediatric radiology fellow and a pediatric radiologist (M.L.G. with 17 years' experience reading MRI), who performed a blinded direct evaluation of the images, rating for quality in terms of motion artifact. Motion scoring was classified by consensus as follows: no motion (0), some motion but diagnostic (1) or nondiagnostic (2). Demographic information, the ability to cooperate/stay still (as per caregiver in requisition form), the use of intravenous contrast enhancement, goggles and anxiolytics, the number of repeat sequences, on-table time and total study time (referring to the total time the patient spent in the MRI suite) were recorded, as well as any motion commented on in the report.

Fig. 2 Our therapy dog and handler providing animal-assisted therapy to our first patient in the program, a 5-year-old girl who went on to successfully achieve her first MRI scan without general anesthesia (permission granted)

Data analysis

Data were analyzed using a mixed-method approach. Descriptive statistics were used to describe the study group and qualitative survey information. Differences between the anxiety-measuring questions on the pre- and post-intervention surveys were tested comparing the mean Likert scores using the Wilcoxon signed rank *t*-test. Results were deemed statistically significant at $p<0.05$.

For quantitative image analysis, cohort MRI studies were paired with two separate control groups identified retrospectively, matched for age, gender and body part being imaged to compare image quality. Control Group 1 consisted of standard MRI performed on awake patients without use of animal-assisted therapy intervention (non-general anesthesia), and Control Group 2 corresponded to scans performed on patients under general anesthesia. Independent samples Student's *t*-test was used to assess for statistical difference between two population means. Level of significance (P) was also set at 0.05. Data were analyzed using IBM SPSS version 14 (Chicago, IL, USA).

Results

Patients

Our pilot group consisted of 21 patients, 47% females (10/21) and 53% males (11/21), with a median age of 8 years (range: 5.1 to 16.5 years). Demographic data are described in Table 1 together with MRI study types and indications. Twelve out of 21 patients (58%) had undergone prior MRI under general anesthesia; for 42% (9/21), it was their first MRI. Seven patients were pet owners (33%) and 17/21 (80%) were native English speakers. No patients or parents/caregivers required a translator. There were 18 unique age, gender and study types in the cohort, as three patient categories each appeared twice.

Table 1 Patient demographics, MRI data and survey responses for patient emotion

ID	Age	Gender	Type of MRI	Indication	5-point Likert scores for patient emotion		
					Pre-scan^	Post-scan#	Deviation
1	10 y 3 m	Male	Brain w/o	Spastic diplegia	2	0	2
2	6 y 2 m	Male	Brain & spine w/o	Urinary incontinence	3	0	3
3	12 y 4 m	Male	Brain & IAC + Gd	Autism, NOMID	4	0	4
4	6 y 7 m	Female	Brain & IAC w/o	Hearing loss	3	2	1
5	6 y 5 m	Female	TMJ + Gd	Psoriatic arthritis	2	0	2
6	6 y 2 m	Male	Brain & spine w/o	Hemivertebra	2	1	1
7	9 y 2 m	Female	Spine w/o	Developmental delay	3	4	−1
8	7 y 4 m	Female	Brain + Gd	Tuberous sclerosis	4	3	1
9	16 y 6 m	Female	Brain + Gd	Seizures	3	2	1
10	8 y 1 m	Female	Face & neck + Gd	Thyroid mass	2	0	2
11	5 y 2 m	Female	Brain w/o	Vertigo	2	1	1
12	7 y 8 m	Male	Hips + Gd	Microvillous disease	2	0	2
13	11 y 8 m	Female	Brain w/o	Developmental delay	4	3	1
14	9 y 2 m	Male	Face & neck w/o	Vascular anomaly	3	0	3
15	5 y 5 m	Female	Brain w/o	Headache	2	0	2
16	5 y 0 m	Male	Brain w/o	Cerebellar anomaly	2	0	2
17	5 y 9 m	Male	Brain w/o	Glaucoma	(−)	(−)	(−) *
18	5 y 1 m	Male	Abdomen + Gd	DICER1 syndrome	4	0	4
19	9 y 1 m	Male	Brain w/o	Epilepsy	3	4	−1
20	5 y 1 m	Male	Wrist w/o	Query Madelung	3	2	1
21	10 y 2 m	Female	Brain w/o	Homocysteinemia	3	0	3

IAC internal auditory canal, *m* months, *MRI* magnetic resonance imaging, *NOMID* neonatal-onset multisystemic inflammatory disease, *TMJ* temporomandibular joints, *w/o* without contrast, *y* years, *+ Gd* with gadolinium-based contrast

*Survey information for Subject 17 not available as patient didn't get into the scanner

^Question: "How do you feel about today's scan?" (Pre-scan)

#Question: "How did you feel during today's scan?" (Post-scan)

Demographic and MRI data for the control groups are detailed in Tables 2 and 3.

Indications for MRI in the cohort group included autism, hearing loss, developmental delay, tuberous sclerosis, psoriatic arthritis, urinary incontinence and spastic diplegia. In 18 out of 21 patients (86%), MRI-compatible goggles were used and 3/21(14%) received an anxiolytic dose of Lorazepam. Seven patients out of 21 (33%) needed insertion of an IV cannula for contrast administration. These parameters are summarized and compared to the control groups in Table 4. The use of goggles in the cohort and non-general anesthesia control groups was similar, as was the need for IV cannulation in all three groups.

Qualitative data: Survey analysis

In the pre-scan surveys, 40% of the patients (8/21) described their overall emotional status as fairly worried, 40% as worried a lot (8/21) and 20% as angry (4/21) before the exam. None of the 21 patients described themselves as relaxed/not worried. Comparatively, in the post-scan survey, relaxed/not worried was circled by 55% of the children (11/21); 30% remained slightly worried (2/21) or fairly worried (3/21) (Fig. 3). Similarly, close to 70% of caregivers (14/21) felt that believed their charges were slightly (7/21, 33%) to fairly (8/21, 38%) worried.

The comparison between the patient's pre- and post-intervention Likert scores demonstrated an average 1.65 point decrease in the median Likert score denoting a significant improvement (Wilcoxon *t*-test, $P<0.01$) (Table 1). Two outliers showed an unexpected 1-point increase in their post-intervention surveys, including a 9-year-old developmentally delayed boy and a 5-year-old girl with DICER1 syndrome. They both shifted from worried a lot to angry when asked how they felt during the scan. Conversely, both patients also stated that the therapy dog made them feel relaxed/not worried. One patient (Patient 17) refused to enter the MRI scanner room. He completed the pre-intervention survey only with a median Likert score of 2; however, he graded his prior MRI scan done under general anesthesia as 4 ("worried a lot"). His survey data were excluded from further analysis.

Table 2 Control Group 1 (without general anesthesia) demographics and MRI data

ID	Age	Gender	Type of MRI	Indication
1	9 y 8 m	Male	Brain w/o	Chiari malformation
2	6 y 5 m	Male	Brain & spine w/o	Seizure
3	11 y 10 m	Male	Brain & IAC + Gd	Headache
4	6 y 6 m	Female	Brain & IAC w/o	Bilateral SNHL
5	7 y	Female	TMJ + Gd	JIA
6	8 y 11 m	Female	Spine w/o	Voiding dysfunction
7	7 y 8 m	Female	Brain + Gd	Tuberous sclerosis
8	16 y 4 m	Female	Brain + Gd	Tumor
9	8 y	Female	Face & neck + Gd	Vascular anomaly
10	5 y 1 m	Female	Brain w/o	Trauma
11	7 y	Male	Hips + Gd	Septic arthritis
12	11 y	Female	Brain w/o	Cavernoma
13	9 y	Female	Face & neck w/o	Vascular anomaly
14	5 y 8 m	Male	Brain w/o	Chiari malformation
15	6 y 1 m	Male	Brain w/o	Seizure
16	5 y 6 m	Male	Abdomen + Gd	Inflammatory bowel disease
17	9 y 8 m	Male	Brain w/o	Chiari malformation
18	5 y 6 m	Male	Wrist w/o	Vascular anomaly

IAC internal auditory canal, *JIA* juvenile idiopathic arthritis, *m* months, *MRI* magnetic resonance imaging, *SNHL* sensorineural hearing loss, *TMJ* temporomandibular joints, *w/o* without contrast, *y* years, *+ Gd* with gadolinium-based contrast

Every participant said they would like to see the therapy dog again on their next visit; 83% (17/21) said the dog made them feel relaxed/not worried on the post-scan surveys. The parents/caregivers expressed similar enthusiasm for the therapy animal's presence: 20 out of 21 (95%) characterized their visit to diagnostic imaging as very good or excellent, and said the dog had been responsible for improving their experience there, citing multiple reasons for this (most commonly that the dog had served as a welcome distraction). All parents/caregivers whose charges had undergone MRI scans previously indicated that this MRI had been an improvement over previous scans. Finally, all but one parent/caregiver expressed a desire to have their child interact with the therapy dog on future visits to diagnostic imaging. The lone caregiver who indicated a disinterest in future visits with the therapy dog explained they believed their child could now cope with the scan on their own. All of the staff members agreed strongly or very strongly that the patient had benefited from the presence of the therapy dog.

Quantitative data: Image analysis

Of the 21 recruited patients, 19 (90%) had diagnostic MRI scans, and two patients failed to complete the exam. Patient 17, a 5-year-old boy being examined for glaucoma, was the patient who refused to go into the MRI scanner room. He did not go on to any further cross-sectional imaging at our institution. The second patient (Patient 14), a 9-year-old boy with a cervical vascular anomaly, could not hold still due to fear and had an incomplete MRI with imaging significantly degraded by motion artifact. This patient proceeded to computed tomography without general anesthesia. Interestingly, in spite of this, the patient reported a positive benefit from interacting with the therapy dog (Table 1). In 11 of the remaining 19 patients (58%), some motion was noted on MRI scans when reviewed by the study readers and recorded by the reporting radiologists; however, all exams were still considered diagnostic.

Average total study time for the final cohort of 19 patients was 63 min and average on-table scan time was 49 min. The mean number of repeated sequences was 1.5. These MRI acquisition data were then compared with the two control groups (Table 4). Both control groups had 100% rate of completion of examinations and 100% of the exams were considered diagnostic, with some motion commented on MRI by the reporting radiologist in 44% of the controls without general anesthesia (8/18). As expected, no motion was commented on in any MRI under general anesthesia. However, no significant differences in the overall exam quality or average exam times (total study time/on-table scan time) were seen when compared against both control groups. The only parameter that proved to be statistically significant was the number of repeat sequences between general anesthesia control MRI (average: 0.7) and the animal-assisted therapy cohort group (average: 1.5); however, this was without a statistically significant increase in exam times (Table 4).

Table 3 Control Group 2 (with general anesthesia) demographics and MRI data

ID	Age	Gender	Type of MRI	Indication
1	10 y 6 m	Male	Brain w/o	PANDAS
2	5 y 8 m	Male	Brain & spine w/o	Loeys-Dietz syndrome
3	11 y 9 m	Male	Brain & spine w/o	Autism
4	7 y	Female	Brain & IAC w/o	SNHL
5	6 y 10 m	Female	TMJ + Gd	Juvenile arthritis
6	9 y 10 m	Female	Spine w/o	Spinal tumor
7	7 y 6 m	Female	Brain + Gd	Encephalitis
8	17 y	Female	Brain w/o	Global developmental delay
9	8 y 2 m	Female	Head & neck + Gd	Tumor
10	4 y 10 m	Female	Brain w/o	Ataxia
11	7 y	Male	Hips + Gd	Osteomyelitis
12	12 y 8 m	Female	Brain w/o	Global developmental delay
13	10 y	Male	Brain & spine + Gd	Tumor
14	5 y 1 m	Male	Brain w/o	Headache
15	5 y 9 m	Male	Abdomen + Gd	Li-Fraumeni syndrome
16	5 y 6 m	Male	Wrist w/o	Vascular anomaly
17	10 y 8 m	Female	Brain w/o	Ataxia
18	5 y 1 m	Male	Brain w/o	Headache

IAC internal auditory canal, *m* months, *MRI* magnetic resonance imaging, *PANDAS* pediatric autoimmune neuropsychiatric disorders associated with streptococcal infections, *SNHL* sensorineural hearing loss, *TMJ* temporomandibular joints, *w/o* without contrast, *y* years, *+ Gd* with gadolinium based contrast

Discussion

Our experience demonstrates that interaction with a therapy dog when preparing for and during MRI, in conjunction with existing strategies, had a beneficial effect on the patients' emotional status, with the majority of patients reporting decreased levels of anxiety in the post-intervention surveys, regardless of age. As well, the majority of our patient cohort (90%) was able to complete diagnostic-quality MRI scans without general anesthesia and without a significant time penalty, notwithstanding most of them being originally considered for general anesthesia. The numbers are slightly lower than the scan success rates reported with other interventions such as certified child life specialist consultation (98.4%) [14] and mock MRI (98%) [8].

The fact that most exams were completed and of diagnostic quality can't be attributed solely to the animal intervention, with existing strategies to facilitate pediatric MRI also used and not controlled for. Eighteen out of 21 of our patients (86%) also used goggles (similar to the control group without general anesthesia, 72%) and 14% (3/21) had anxiolytic agents administered. Similarly, the improved emotional status is also multifactorial. Conceivably, both patients and caregivers could have had decreased levels of anxiety simply because the exam was over. Another limitation of our study is the heterogeneity of the study group, which varied in age and pathology, the range of indications being typical for a tertiary pediatric center, with the majority of MRI scans under general anesthesia performed for neurological investigations. As such, more than a third had some degree of developmental delay, variable in severity, including seizure disorder, autism and hearing loss. It is possible these patients preferentially benefited from the animal intervention. That the survey administrator was present during the filling out of the questionnaires also needs to be acknowledged as a potential source of bias, although care was taken to avoid influencing within the limits of possible. Finally, as in many animal-assisted therapy studies, there is also an intrinsic selection flaw in our design as previous engagement with animals affects the participants' reactions to the intervention. Recruitment is largely based on the patients' past relationships with animals, excluding those who dislike or fear dogs. However, less than half of our patients were pet owners, and the positive mood variation was not limited to them, suggesting the results of this interaction are not restricted to individuals with previous positive interaction with dogs.

Despite these limitations, we might also speculate that interaction with the therapy animal in the waiting room and during the IV placement acts as a powerful distraction in a crucial moment of increased anxiety for both children and parents as previously described by Viggiano et al. [1]. At the same time, other children and adults in the room inevitably noted the unusual presence of a dog, creating a generally relaxing atmosphere that eased the tension of both children and their parents/caregivers and may also affect the mood of the MRI staff, thus improving their interactions with the patients.

Table 4 Summary and comparison of demographics, MRI acquisition data and image quality review of animal-assisted therapy cohort and control groups

	Animal-assisted therapy cohort	Control Group 1 (without general anesthesia)	Control Group 2 (with general anesthesia)
Patients (*n*)	21	18*	18*
Age (average/range, years)	8.0/5.1–16.5	7.8/5.1–16.3	8.0/4.8–17.0
Gender composition	10F, 11 M	9F, 9 M	9F, 9 M
Unable to stay still/cooperate for ~60 min ^	18/21 (85%)	2/18 (11%)	18/18 (100%)
IV, *n* (%)	7/21 (33%)	7/18 (38%)	6/18 (33%)
Goggles, *n* (%)	18/21 (85%)	13/18 (72%)	NA
MRI completion, *n* (%)	19/21 (92%)	18/18 (100%)	18/18 (100%)
Reported motion, *n* (%)	11/19 (52%)	8/18 (44%)	0/18 (0%)
Reviewed motion 0,1,2 - *n* (%)	0=5/19 (27%) 1=11/19 (73%) 2=0/19 (0%)	0=12/18 (67%) 1=6/18 (33%) 2=0/18 (0%)	0=13/13 (100%) 1=0 (0%) 2=0 (0%)
Mean number repeat sequences (absolute value, *p*-value)	1.5	1.28 (0.42)	0.7 (**<0.005**)
On-table scan time (min, *p*-value)	49 min	44 min (0.13)	46 min (0.5)
Total study time (min, *p*-value)	63 min	56 min (0.44)	58 min (0.29)

F females, *IV* intravenous line, *M* males, *MRI* magnetic resonance imaging, *n* number of patients, *NA* non-applicable

Reviewed motion: 0=no motion, 1=some motion but diagnostic, 2=nondiagnostic

Reported motion: 0=no, 1=yes

p-value (level of significance): <0.05; Bold indicates statistical significance

*There were only 18 unique age, gender and study types in the cohort; 3 patient categories appeared twice each

^ Answer on requisition form completed by caregiver/referring physician, or failed prior non-sedation

Animal-assisted therapy has come a long way in achieving its status as a respectable form of therapy, but there is still the question of whether the training both pets and handlers receive is effective and rigorous [18], remaining largely unregulated despite its increased use in various health care settings around the world. On the other hand, it is difficult to compare the effectiveness of animal-assisted therapy to other non-pharmacological approaches [1]. Only a handful of studies have been conducted to quantify the efficacy of animal-assisted therapy in pediatrics [21–26] and very scarce attention has been devoted to this topic in the radiologic literature. Many of these studies have been, like ours, observational or correlational and few have included a control group [1]. Viggiano et al. [1] prospectively enrolled 65 children in three non-pharmacological interactions and applied surveys to the intervention and control groups, with results showing these activities were highly effective in improving emotional status, reducing anxiety and fear, and decreasing the need for

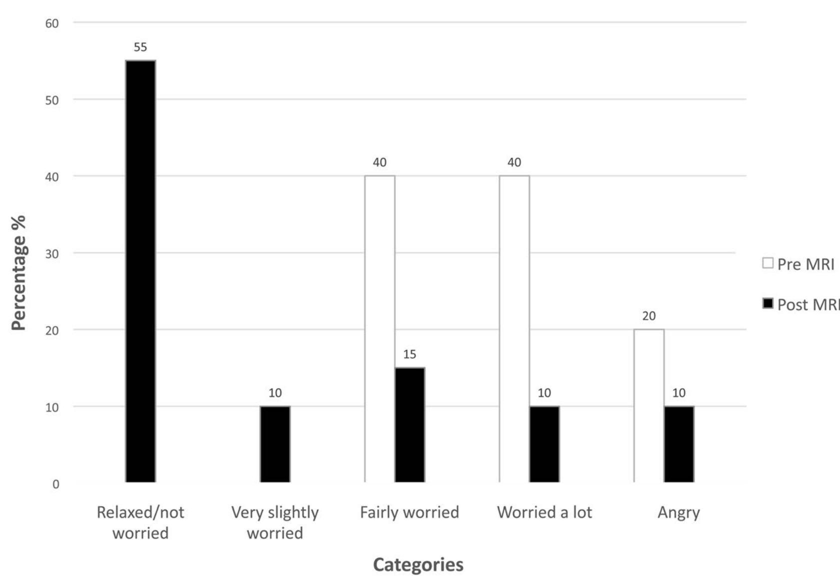

Fig. 3 Responses (Likert scores) to patient emotion questions pre- and post-MRI scans

sedation in the experimental group compared to the control group, without separating the effect of different interventions. Similarly, we did not separate the different interventions supplementing animal-assisted therapy. In contrast, we did not use a control group for levels of anxiety, instead using individual patient experience as a comparison, focusing on MRI diagnostic quality and study duration measured against the control groups.

For units interested in developing animal-assisted therapy protocols, important decisions include interdisciplinary involvement (including from infection control colleagues) and specifying inclusion/exclusion criteria of patients. Guidelines from the Centers for Disease Control and Prevention require that therapy animals be clean, healthy, fully vaccinated and free of enteric parasites [34, 35]. By attending to such principles, animal-assisted therapy can promote environmental spaces that are truly transformational for both patients and staff. Several successful examples of these programs in critical care units can be found.

A not infrequent issue we encountered was the delay between scheduled and actual scan times, which are difficult to anticipate and which become problematic for therapy dogs. Their visits are limited to a maximum period of 2 h because there is evidence that maintaining a high level of obedience and calm instead of engaging in play, and accepting handling from strangers, requires work and effort by the therapy dog [20]. Thus, the intervention is nearly impossible to organize on an urgent basis, as this would require the full-time availability of a therapy dog. Also, as people who bring their animals to long-term care facilities do so on a volunteer basis, it can be difficult to establish a consistent schedule. We are fortunate to be able to reliably schedule MRI scans with a therapy dog and handler.

Animal-assisted therapy services are volunteer-based, and thus no extra funding is needed in centers with a preexisting program like ours. Our only additional cost was the clinical research assistant who applied a number of the surveys (approx. $25/h) and who was employed during the pilot study. This is not an ongoing cost, with patient selection and scheduling utilizing the usual MRI pathways and team members. Based on the success of this Quality Improvement initiative, animal-assisted therapy has now been adopted as standard of care in our department to improve the patient experience reducing anxiety in MRI and potentially reducing the need for deep sedation/general anesthesia. As such, we have recently incorporated a second therapy dog-handler team, allowing a small but growing number of patients to benefit from this program. To date, this intervention has enabled us to perform diagnostic quality MRI scans without general anesthesia in children as young as 3 years, 4 months.

Conclusion

Our Quality Improvement project shows that interaction with therapy dogs can have a beneficial effect in modulating negative emotions in preparing children for MRI while still achieving diagnostic quality scans. As emotional state is related to the need for sedation, the intervention may ultimately contribute to reducing the need for sedation/general anesthesia. Given the growing body of evidence regarding the impact of general anesthesia on neurocognitive development, novel approaches such as this are being sought. As with other techniques for facilitating awake MRI, animal-assisted therapy should be tailored to a patient's age and developmental needs. Further randomized studies will be needed to demonstrate its contribution to reducing general anesthesia rates in children undergoing MRI scans.

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Compliance with ethical standards

Conflicts of interest None

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