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Using a checklist to assess if a child undergoing MRI needs general anaesthesia

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AIM: To assess if a child-assessment checklist covering tasks children are expected to perform during magnetic resonance imaging (MRI) can determine whether the child requires general anaesthesia (GA) during MRI.

MATERIALS AND METHODS: In this institute review board approved study, children who underwent MRI from September 2016 to June 2017 at KK Women's and Children's Hospital were assessed using a checklist by a research assistant before their examination. During this project, the checklist had no influence on whether the MRI was performed under GA or not. The checklist consisted of five items rated on a binary scale assessing the child's behaviour. Binary logistic regression was performed separately on the overall sample and for a subset of younger children to identify variables associated with the requirement for GA.

RESULTS: The mean age of the overall sample (798 children) and the subset of children <8 years (124 children) were 11.7±3.7 and 5.5±1.3 years, respectively. In both groups, children who required GA were significantly younger than those who did not ($p<0.001$). No gender differences were observed. Children who required GA scored higher on the checklist compared to those who did not in both groups ($p<0.001$). The diagnostic accuracy of the checklist was found to be good (area under the curve [AUC]=0.97 for both groups), with a suggested cut-off score of 4. Intraclass correlation coefficient of the ratings by two independent individuals was 0.78.

CONCLUSION: The child assessment checklist was useful in identifying GA requirement in children undergoing MRI and can be administered by non-medical staff with good inter-rater reliability.

Introduction

Magnetic resonance imaging (MRI) is an optimal imaging method for children, as it is free from ionising radiation and precise[1]; however, MRI is sensitive to motion[1,2] and can be lengthy, with a session lasting approximately 45

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minutes.[2–4] It is noisy in the scanner[3,4] and it may be hard for children to remain still while undergoing MRI.

Hart[5] observed that children between the ages of 2–10 years were more anxious when they entered the imaging room, and their anxiety level intensifying during pre-scan procedures when the equipment was being shifted and when instructed to lie down and keep still. To prevent movement in children for a successful scan, general anaesthesia (GA) or sedation may be used.[1,2] Sedation or GA is routinely given to younger children 6–8 years undergoing MRI, as children >7 years are able to obey instructions and keep still during scan[6–8]; however, Hallowell and colleagues[6] also found that some younger children <5 years were able to undergo MRI without the use of GA when provided with sufficient, age-appropriate preparation.

Use of sedation and GA is expensive and are not without risks and adverse effects.[3,9–11] Although it has been suggested that the use of GA and sedation is generally safe and risks can be minimised with the use of standardised protocols, along with the presence of trained personnel and appropriate equipment,[4,7] various studies have reported on risks associated with their use. Some have reported long-term effects on patients, whereas others report distress to the patients, their family members, and medical staff.[3,9,10,12,13] Risks include adverse response to the medications used for sedation, respiratory depression, and inability to maintain airway, which may lead to cardiac arrest, prolonged restlessness, emergence delirium (a state of dissociation and irritation, which is more likely to occur in young children following discontinuation of GA), delayed side effects such as agitation and difficulty with breathing after discharge, as well as potential long-term behavioural and neurocognitive issues.[3,9–13] Furthermore, the use of GA and sedation increases cost as extra manpower, magnetic resonance (MR)-compatible equipment and drugs are required.[4,6]

A study by Thung and colleagues[14] found that the modified Yale Preoperative Anxiety Scale (mYPAS) was useful in identifying children who would benefit from mock scanner training prior to their MRI; however, children who scored high on the scale prior to the training session continued to have high scores on the mYPAS following the training session.[14] As mock scanners and certified child life specialists are not readily available in many hospitals, a screening tool to distinguish between children who are able to successfully complete MRI without sedation or GA and those who are not would be more useful in many hospitals.

The present authors created a brief screening tool, consisting of a short checklist of five items based on the tasks the children need to perform in order to undergo an MRI examination successfully. In the past, the determination of whether the child requires GA is made by the referring clinician who has interacted with the child during the clinic consultation and allocation was based on the referring clinician's subjective opinion of whether child could keep still for MRI with no documentation regarding the cooperativeness of the child or ability of the child to keep still. Regarding patients whom the referring clinician did not specify GA requirement, it was left to the MRI nurses to discuss with parents whether they would like to attempt a non-GA MRI or directly schedule the child for MRI under GA, again with lack of documentation of how the decision was reached. With referrals coming from external institutions and no formal screening with regard to the cooperativeness of the child, an objective tool that will help staff identify individuals who are able to remain still in the imaging department will better allow triage of the children.

The aims of this study were (1) to examine whether the child assessment checklist administered by non-clinical staff is useful in assessing GA requirement in children in general, and (2) in a younger subset of children between the ages of 3–7 years.

Materials and methods

Study population

Seven hundred and ninety-eight children and young adults aged 3–20 years scheduled to undergo MRI from September 2016 to June 2017 were assessed with the child assessment checklist by an MRI research assistant prior to their MRI examination. A subset of 40 children was assessed by two raters (a medical student and a research assistant) independently over 2 weeks to assess for inter-rater reliability. Information whether the child's MRI examination was performed under GA was captured and the checklist had no influence on this during the project. Participants in the study were consecutively recruited by a research assistant for a randomised controlled trial assessing the effectiveness of pre-MRI educational videos to prepare children for MRI with predefined criteria. Children and young adults aged 3 years up to 21 years old were included irrespective of the body region being scanned and irrespective of the requirement for intravenous contrast medium. Children who were unable to communicate, such as intubated patients from the intensive care unit, autistic children, those with Down's syndrome, or with an altered mental state, were excluded. All participants and staff were blinded, apart for the individual performing the randomisation, as to whether the child was offered videos/games prior to the MRI. As the videos were not found to affect the requirement for GA,[15] children who were and who were not shown videos were included. Verbal consent was obtained from parents and children between 13–20 years old, while verbal assent was obtained from children between 6–12 years of age. This study was approved by the ethics committee. Seven hundred and twenty children underwent MRI successfully without GA and 76 underwent MRI under GA, with diagnostic images obtained for all of these patients. Data from one child (6 years old) was excluded from analysis as the child was able to keep still but was unable to breath-hold for at least 20 seconds.

Child assessment checklist

The checklist assesses the child's behaviour in four areas: restlessness, attention span, distractibility, and ability to comply with instructions, based on the rater's observation

of the child's behaviour. The items covered in the scale are tasks that children are expected to perform during their MRI examination. Items are rated on a binary scale (yes or no). A response of "yes" on items 1, 2, and 5, "no" on items 3 and 4 was awarded one point each.

Questions in the checklist were: (1) is the child able to sit on the chair for 10 minutes (without being restless)? (2) Is the child able to attend an activity for 10 minutes? (3) Is the child easily distracted by other people in the room? (4) Does the child wander about the waiting area during this interview? (5) Is the child able to obey commands and instructions during the interview?

Question 1 on the checklist was more generic and was intended to assess the general activity of the child. Question 2 is more specific and assesses the attention span of the child. A child can be preoccupied with an activity and thus be able to sit quietly for 10 minutes, but the converse may not hold true. Activities were not predefined, but usually up to the parent–child pair. For example, the parent may get the child to read a book, watch a cartoon being shown on the television set at the MRI reception area, or allow the child to play games on his or her mobile phone.

It takes <2 minutes to tick the answers to the checklist questions and calculate the checklist score. The assessor would have 10 minutes to observe the child as the parent does the registration paperwork at the counter and as the counter staff keyed in the details into the computer, this process taking approximately 10 minutes.

Statistical analysis

Demographic characteristics of the two groups (children who did not require GA and those who did) were compared using independent *t*-tests or chi-square tests, as appropriate. This was carried out for both the overall samples and the subset of the younger age group aged 3–7 years. The total checklist score was compared between the groups using the independent *t*-test.

Binary logistic regression was carried out with MRI examination with and without GA as the outcome of interest. Factors entered into the model included age and total checklist score. The receiver operating characteristic (ROC) curves as well as the areas under the ROC curves (AUROC) for both overall sample and subset were calculated to assess whether the total checklist score was a good assessor of GA requirement. The strengths of individual checklist items in predicting GA requirement in the sample of children undergoing MRI was also assessed.

The intraclass correlation coefficient (ICC) of the ratings on the total checklist score by two independent individuals was assessed for 78 children, to measure the inter-rater reliability between the two independent raters. All statistical analyses were conducted using SPSS 19.0 (IBM, Armonk, NY, USA). Statistical significance was set at $p<0.05$ (two tailed).

Results

Demographic features

The mean age of the children and young adults was 11.7±3.7 years whereas the mean age of the subset of 124 younger children was 5.5±1.3 years. Children in the no GA group were significantly older than the children in the GA group, the same was observed in the subset of 124 children ($p<0.001$; Table 1). No gender differences were observed.

Comparison of checklist scores between groups

Comparison of the total checklist scores between no GA and GA in the total sample of 798 children showed that the no GA group had significantly higher checklist scores compared to their counterparts requiring GA ($p<0.001$; Table 1). In the subset of younger children, children without GA had statistically higher scores compared to those who had GA ($p<0.001$; Table 1).

Variables associated with GA requirement in children undergoing MRI

Within the overall sample of 798 children, age and total checklist scores correctly classified 98.5% of the cases. Increase in age and increase in total checklist scores were found to be associated with an increased likelihood of not

Table 1
Characteristics of all children.

		No GA	GA	Between group differences
All patients	*n*=798	*n*=721	*n*=77	*p*-Value
Age (SD), years	11.7 (3.7)	12.4 (3.1)	5.2 (1.8)	<0.001*
Sex (N, %)				0.160
Male	385 (48.2)	342 (47.4)	43 (55.8)	
Female	413 (51.8)	379 (52.6)	34 (44.2)	
Total Checklist Score	4.61 (0.96)	4.88 (0.37)	2.10 (1.13)	<0.001*
Characteristics of subset of children aged 3–7 years	*n*=124	*n*=54	*n*=70	*p*-Value
Age (SD), years	5.5 (1.3)	6.4 (0.8)	4.8 (1.2)	<0.001*
Sex (N, %)				0.213
Male	63 (50.8)	24 (44.4)	39 (55.7)	
Female	61 (49.2)	30 (55.6)	31 (44.3)	
Total checklist score	3.17 (1.58)	4.63 (0.62)	2.04 (1.08)	<0.001*

* Significance at $p<0.05$.
GA, general anaesthesia.

requiring GA ($p<0.001$; Table 2). The Hosmer–Lemeshow test yielded a χ^2 (7) of 3.78 and was found to be insignificant ($p>0.05$), suggesting that the model fit the data well.[16]

For the subset of 124 children, age and total checklist scores correctly classified 93.5% of the cases. The only increase in total checklist score was found to be associated with an increase in the likelihood of not requiring GA ($p<0.001$; Table 2). The Hosmer–Lemeshow test yielded a χ^2 (7) of 2.70 and was found to be insignificant ($p>0.05$), suggesting that the model fit the data well.[16]

Use of checklist to assess GA requirement

The child assessment checklist was found to correlate well with the need for GA in both the overall sample, as well as the subset of younger children (AUROC of 0.974 with 95% confidence interval [CI]=0.947 to 1.000 for the former, and AUROC of 0.966 with 95% CI=0.934 to 0.997 for the latter respectively (Table 3).

A total checklist score of 4 was found to be the optimum value based on the ROC curves for all children (sensitivity 98.3%, specificity 92.2%) as well as the subset of younger children (sensitivity 92.6%, specificity 94.3%).

All five items in the checklist were significantly associated with GA requirement, with item 5 on the child's ability to obey instructions having the strongest association with not requiring GA when undergoing scan, odds ratio of 71.80 (Table 4).

For the younger children between aged 3–7 years, only three items on the checklist were found to be significantly associated with GA requirement. They are items regarding the child's restlessness, distractibility, and ability to obey instructions (questions 1, 3, and 5). Similar to the findings in the overall sample, item 5 on the child's ability to obey instructions was found to have the strongest association with not requiring GA when undergoing MRI (odds ratio of 20.5, Table 4).

Table 3
AUROC, sensitivity and specificity for checklist items in predicting GA requirement.

	AUROC	Sensitivity	Specificity
Overall sample			
Question 1	0.895	97.2%	81.8%
Question 2	0.595	99.6%	19.5%
Question 3	0.868	93.1%	80.5%
Question 4	0.711	99.3%	42.9%
Question 5	0.826	98.9%	66.2%
Total checklist score	0.974	98.3%	92.2%
Subset of children aged 3–7 years			
Question 1	0.866	89.9%	84.3%
Question 2	0.600	100%	20%
Question 3	0.817	83.3%	80%
Question 4	0.694	94.4%	44.3%
Question 5	0.824	96.3%	68.6%
Total checklist score	0.966	92.6%	94.3%

Over the age of 7 years, few children require GA for MRI. The total number of children in each age group, those who required GA and those who did not require GA, is shown in Table 5 and converted into percentages for illustration in Fig 1.

Inter-rater reliability between the two independent raters

The level of inter-rater reliability was moderate to good between the two independent raters. The single measure ICC was 0.78, with 95% CI=0.68 to 0.85.

Discussion

This study shows that the total checklist scores differed significantly between children who required GA during MRI and their counterparts who did not, with the latter obtaining significantly higher scores. This was observed in all children,

Table 2
Logistic regression analyses on variables associated with GA requirement during MRI scan.

Predictor	β	*p*-Value	eβ (odds ratio)	95% CIs for Odds Ratio
Overall sample (*n*=798)				
Constant	11.688	<0.001	NA	
Age	-0.618	<0.001*	0.539*	(0.402, 0.722)
Total checklist score	-2.282	<0.001*	0.102*	(0.051, 0.203)
Test	χ^2	*df*	*p*-Value	
Overall model evaluation	424.339	2	<0.001	
Score test	590.385	2	<0.001	
Wald test	348.089	1	<0.001	
Subset of younger children (*n*=124)				
Constant	10.256	<0.001	NA	
Age	-0.295	0.429	0.754	(0.359, 1.546)
Total checklist score	-2.383	<0.001*	0.092*	(0.034, 0.250)
Test	χ^2	*df*	*p*-Value	
Overall model evaluation	118.803	2	<0.001	
Score test	84.572	2	<0.001	
Wald test	2.053	1	0.152	

Overall Sample: Nagelkerke R^2=0.878.
Subset of younger children: Nagelkerke R^2=0.826.
* Significance at $p<0.05$.

Table 4
Logistic regression analyses on checklist items in predicting GA requirement.

Predictor	β	*p*-Value	*e*β (odds ratio)	95% CIs for Odds Ratio
Overall sample (*n*=798)				
Constant	-5.804	<0.001	NA	
Question 1 (Restlessness – remain in chair ≥10 min)	3.419	<0.001*	30.539*	(9.782, 95.340)
Question 2 (Attention span)	2.586	<0.05*	13.278*	(1.797, 98.122)
Question 3 (Distractibility)	2.810	<0.001*	16.616*	(5.212, 52.973)
Question 4 (Restlessness in waiting area)	2.462	<0.01*	11.724*	(2.034, 67.578)
Question 5 (Ability to obey instructions)	4.274	<0.001*	71.801*	(17.352, 297.100)
Test	χ^2	*df*	*p*-Value	
Overall model evaluation	403.126	5	<0.001	
Score test	603.490	5	<0.001	
Wald test	348.089	1	<0.001	
Subset of younger children (*n*=124)				
Constant	-3.555	<0.001	NA	
Question 1 (Restlessness – remain in chair ≥10 min)	2.566	<0.01*	1 3.016*	(2.863, 59.174)
Question 2 (Attention span)	19.829	0.998	4.088E8	
Question 3 (Distractibility)	2.342	<0.01*	10.406*	(2.235, 48.457)
Question 4 (Restlessness in waiting area)	1.729	0.112	5.633	(0.668, 47.515)
Question 5 (Ability to obey instructions)	3.020	<0.01*	20.496*	(3.213, 130.737)
Test	χ^2	*df*	*p*-Value	
Overall model evaluation	120.585	5	<0.001	
Score test	87.674	5	<0.001	
Wald test	2.053	1	0.152	

Overall Sample: Nagelkerke R^2=0.844.
Subset of younger children: Nagelkerke R^2=0.834.
* Significance at $p<0.05$.

as well as in the subset of younger children. In the overall sample, both age and checklist scores were found to be associated with GA requirement. Within the group of interest, children aged between 3–7 years, only the total checklist score was found to be associated with GA requirement. A cut-off point of ≥4 was identified as the optimal threshold in identifying children that did not require GA in both the overall sample and the subset of younger children. Out of all five items in the checklist, item 5, which assessed the child's ability to obey instructions, was found to have the strongest association with not requiring GA in both the overall sample and the subset of younger children. Finally, the inter-rater reliability of the checklist by two independent individuals is moderate to good.

Table 5
Total number of children in each age group and those who required GA.

Age	Total no. of children	No. of children requiring GA	Percentage of children requiring GA	No. of children not requiring GA	Percentage of children not requiring GA
3	12	12	100%	0	0%
4	19	17	89.4%	2	10.5%
5	29	23	79.3%	6	20.7%
6	28	11	39.3%	17	60.7%
7	36	6	16.7%	30	83.3%
8	45	3	6.7%	42	93.3%
9	54	2	3.7%	52	96.3%
10	58	1	1.7%	57	98.3%
11	47	0	0%	47	100%
12	71	1	1.4%	70	98.6%
13	93	0	0%	90	96.8%
14	116	0	0%	116	100%
15	103	0	0%	103	100%
16	46	0	0%	46	100%
17	13	0	0%	13	100%
18	16	0	0%	16	100%
19	6	0	0%	6	100%
20	6	0	0%	6	100%

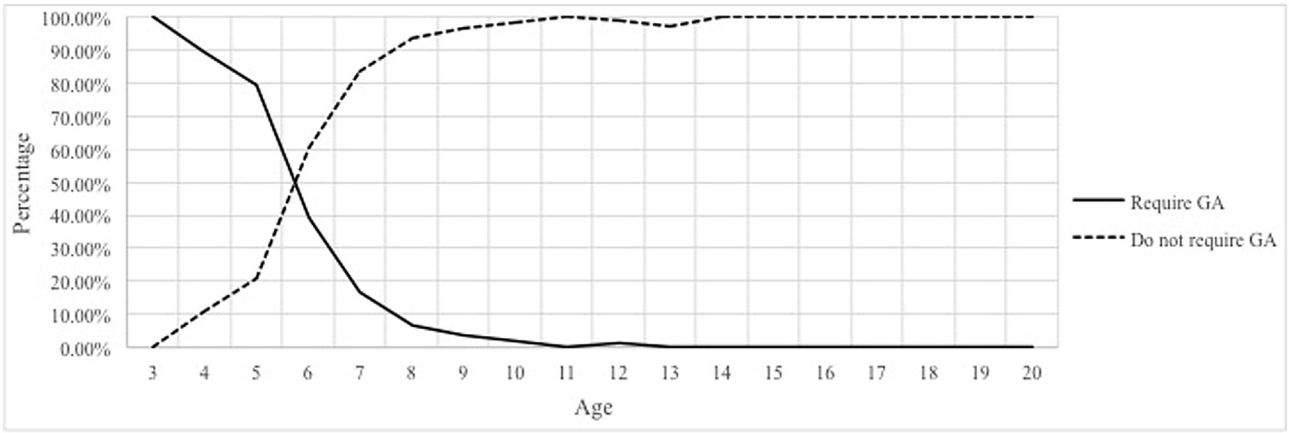

Figure 1 Children who required GA and those who did not require GA in each age group.

Arlachov and Ganatra[17] suggested that it is beneficial to assess whether patients will require GA or sedation before their scan and use the appropriate technique accordingly, instead of having the patient go through scan without external aids, and failing the scan in the process, thereby requiring rescheduling the scan and use of GA or sedation. This child assessment checklist can be completed within 2 minutes as it only consists of five questions, and is based on the observations by staff of the child at the waiting area. Hence, the use of this checklist will not interfere with the flow of procedures, or require specialised staff,[14] and the assessor can start observing the child's behaviour the moment the child enters the clinic or waiting area. Appointments for non-urgent MRI are usually made several days or weeks in advance and the checklist can be easily used by counter staff to assess children's need for GA or sedation.

Few studies have examined the use of screening tools that can potentially be used to identify children who will require GA while undergoing MRI, and different studies have assessed the use of different scales.[14,18] Thung *et al.*[14] found that the mYPAS, which assessed preoperative anxiety, was useful as a brief screening tool to identify children that could successfully complete MRI without the use of GA, by identifying children that will benefit from mock scanner training prior to their scan rather than who could or could not undergo the scan without GA or sedation; however, they only assessed 80 children >5 years in their study and did not assess children <5 years of age, whereas the present cohort is larger and the age range went down to those aged 3 years. An earlier study by Napp and colleagues[18] assessed the effectiveness of the claustrophobia questionnaire (CLQ) in predicting the frequency in occurrence of claustrophobic events in patients arranged to undergo MRI. They assessed approximately 6,500 adult patients and found that although the CLQ was useful in identifying those at risk of claustrophobia, it was not useful in predicting risk for individual patients.[18] This is less relevant for us as claustrophobia is not an issue in children.[6,19]

The time required for administration of the checklist is short, similar to the mYPAS in Thung and colleagues' study.[14] It consists of only five questions based on the child's behaviour in the waiting area and correlated well with GA requirement in the present study. The checklist can be completed by non-clinical staff that have the opportunity to observe the child's behaviour prior to the examination, and does not require the presence of certified child life specialists. As inter-rater reliability was found to be good, based on the ratings by two independent raters (one a medical student, the other a research assistant who was previously a counter staff), the checklist has the potential to be administered by any hospital personnel, even non-medical staff. The checklist would be most easily performed by counter staff when the child and parent come to the department to arrange their MRI appointment.

Age is a good indicator, as children >7 years are able to comply with instructions[8]; however, for children between aged 3–7 years, findings are not as consistent,[2,5,6,13] although these younger children show greater ability to undergo MRI without GA with increasing age. Thus the checklist is most useful in determining which of these children between aged 3–7 years can undergo MRI without GA. A total checklist score of 4 is the optimal value in demarcating between children not requiring GA from those who do. Children scoring ≥4 on the checklist were less likely to require the use of GA during MRI, and the checklist is especially useful in this subset of younger children where it can assist in predicting GA requirement.

Out of the five items in the checklist, item 5 assessing the child's ability to obey instructions was found to have the greatest association with GA requirement, with a higher score on this item being associated with a reduced likelihood of requiring the use of GA. This indicates that compliance with instructions is most important in ensuring that children will remain still during their MRI examination. The ability to comply with instructions has been found to be one of the determining factors in identifying children who require GA or sedation for their MRI examination, as reported by Lawson,[8] who noted that because children >7 years were able to obey instructions to keep still, it is mainly children between ages of 1–7 years who require sedation during their scan. Ali *et al.*[20]

also suggested that in order to acquire scans with adequate image quality, patients have to be able to obey instructions provided by the radiology personnel performing the procedures both prior to and during the examination. The present findings therefore reinforce the importance of patients' ability to comply with instructions provided by radiographers both before and during the MRI in ensuring a successful scan.

Limitations

As the children assessed are those who participated in the video project, there is the possibility of there being a bias where the participants may significantly differ from those who did not agree to participate in the study. Hence, the sample of data included in this study may not be completely representative of the population.[21]

In addition, it was not assessed if MRI examinations of different body regions are associated with differences in GA requirement. It has been reported that patients may find it easier to remain still within the scanner and not require anaesthesia for body parts, such as the brain and limbs, compared to abdominal imaging where patients are required to hold their breath several times during the scan.[3]

Future studies can look into whether non-medical staff in adult hospitals with less frequent exposure to children would be able to use this checklist successfully.

In conclusion, the child assessment checklist administered by non-clinical staff is useful in assessing GA requirement in children, correlating well with GA requirement in children undergoing MRI, and showing good inter-rater reliability. The item assessing the child's ability to obey instructions was found to have the greatest association with not requiring GA during MRI.

Conflict of interest

The authors declare no conflict of interest.

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