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ARAŞTIRMA / RESEARCH

Incidence of complications in anesthesia applications during magnetic resonance imaging in pediatric patients

Pediatrik hastalarda manyetik rezonans görüntüleme sırasında anestezi uygulamalarında görülen komplikasyonların insidansı

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Abstract

Purpose: The aim of this study was to investigate complications during sedation of pediatric patients undergoing Magnetic Resonance Imaging (MRI) to determine precautions to take to minimize complications while providing a safer environment for patients and healthcare workers.

Materials and Methods: The files of consecutive patients taken for 6 months in the MRI unit of our hospital were reviewed retrospectively, and a total of 122 pediatric patients were included. Primary parameter in the study is set as peroperative and postoperative complication incidence. Interventions to treat, demographic data, ASA scores, accompanying diseases, agents and their doses for sedation, sedation and recovery time are the secondary parameters and their correlation to complication incidence is assessed.

Results: Using the data of 122 patients, complication rate is found as 6.6% (8/122). During sedation, desaturation in 6, bradycardia and desaturation in 1 and airway obstruction in 1 of the patients was observed. Desaturation was seen in 2, bradycardia was seen in 1 of the patients during recovery. Use of ketamine didn't decrease the dose of midazolam or propofol used for maintenance but decreased the dose of propofol used for induction.

Conclusion: Complications may occur despite the presence of an experienced anesthesia team. It is important to anticipate such complications and intervene in a timely manner.

Keywords:. MRI, non-operating room anesthesia, complication

Öz

Amaç: Çalışmamızda, Manyetik Rezonans Görüntüleme (MRG) Ünitesi'nde anestezi altında görüntüleme yapılan pediatrik hastalarda, uygulanan sedasyona bağlı gelişen komplikasyonları inceleyip; bu komplikasyonları daha aza indirmek için gereken önlemleri tespit ederek, hasta ve sağlık personeline daha güvenli bir ortam sağlanması amaçlanmıştır.

Gereç ve Yöntem: MRG Ünitesi'nde 6 ay boyunca alınan hastaların dosyaları retrospektif olarak incelenip, toplam 122 pediatrik hasta çalışmaya dahil edilmiştir. Çalışmadaki birincil parametre, peroperatif ve postoperatif komplikasyon insidansı olarak belirlenmiştir. Bu komplikasyonlara olan müdahale yöntemleri, demografik verileri, ASA skorları, eşlik eden hastalıkları, kullanılan anestezik ajanlar ve dozları, sedasyon ve derlenme süreleri ikincil parametreler olarak incelenmiş; komplikasyon insidansı ile korelasyonları değerlendirilmiştir.

Bulgular: Toplam 122 hastaya ait veriler çalışmaya dahil edilmiş; komplikasyon oranı %6.6 (8/122) olarak tespit edilmiştir. Sedasyon süresince; 6 hastada desaturasyon, 1 hastada bradikardi ve desaturasyon, 1 hastada havayolu obstrüksiyonu saptanmıştır. Derlenme sırasında, 2 hastada desaturasyon, 1 hastada bradikardi gelişmiştir. Ketamin kullanılan hastalardaki diğer anestezik ajanların dozlarında herhangi bir azalma olup olmadığı incelendiğinde midazolam dozunun ve idamede kullanılan propofol dozunun azalmadığı; ancak, indüksiyonda kullanılan propofol dozunun anlamlı şekilde azaldığı görülmüştür.

Sonuç: MRG için anestezi sırasında, deneyimli bir anestezi ekibinin varlığına rağmen komplikasyonlar oluşabilir. Bu tür komplikasyonların öngörülmesi ve zamanında müdahale edilebilmesi için hazırlıklı olmak önemlidir.

Anahtar kelimeler: MRG, ameliyathane dışı anestezi, komplikasyon

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INTRODUCTION

Today, the need for Magnetic Resonance Imaging (MRI) is increasing in pediatric patients for accurate diagnosis and appropriate treatment. Patients in the pediatric age group have to lie still within the time required for MRI examination. Considering this noisy and claustrophobic environment, in this age group; sedation is required in order to eliminate factors that may impair the effectiveness of MRI, such as movement, discomfort, pain, and anxiety[1,2]. Since these procedures are usually planned outpatient, it should be kept in mind that rapid recovery and side effects should be kept to a minimum in sedation application[2].

Various anesthetic agents are generally administered for sedation of pediatric patients during MRI; they are used to minimize the artifacts caused by motion[3]. Propofol, which is often preferred, can cause airway obstruction, respiratory depression, hypotension and bradycardia if used in high doses for deep sedation. However, when used in low doses, it may cause the test to fail and be repeated due to the patient's movement[2].

Anesthesia and sedation in pediatric patients in the non-operating room environment is a current issue. It is a matter of debate who will be the implementer. It has been found that the presence of an anesthesiologist is more reliable compared to studies conducted on who will administer anesthesia to patients in a non-operating room environment[4]. Static and magnetic fields can cause difficulties in anesthesia management and follow-up (visual limitation, dark environment, noise, etc.). A systematic approach similar to anesthesia provided in traditional operating room conditions (such as pre-sedation fasting and thirst, informed consent, airway examination, patient history, family history, previous sedation experiences, electrocardiogram (ECG), pulse oximetry (SpO_2), noninvasive blood pressure (NIBP), trained personnel, adequate planning, anesthesia machine) should be applied. In an MRI environment where traditional operating room conditions are not available, a senior anesthesiologist should be present for emergency conditions[5-7]. Although the presence of an anesthesiologist is considered more reliable during these procedures, it should not be forgotten that some complications may develop. In a study comparing sedation practitioners from different specialties in terms of complications that may develop; it has been shown that the lowest complication rate with 7.6% is in anesthesiologists[8]. As well as preventing complications, it is also important to be able to intervene quickly and accurately when they develop.

In our study, we aimed to determine the peroperative and postoperative complications that can be seen frequently even in the presence of an anesthesiologist, in order to prevent complications and to perform the necessary intervention quickly and accurately in pediatric patients undergoing sedation in the MRI Unit of our tertiary hospital.

We aimed to determine the complications seen during anesthetic interventions for MRI in pediatric patients and their incidence. Although there is an experienced anesthesia team, various complications may develop in pediatric patients during sedation in the MRI Unit, which is one of the non-operating room anesthesia (NORA) locations. We believe that the prediction of these complications and the timely intervention will improve perioperative and postoperative morbidity and mortality rates.

MATERIALS AND METHODS

This study is a retrospective study conducted in Hacettepe University Hospital. Written approval for the study was obtained from Hacettepe University Non-Interventional Clinical Research Ethics Committee with registration number GO 15/493, number 16969557-845 and dated 22.07.2015. Consent was obtained from the families of all participants for the study. The files of pediatric patients who were sedated in the MRI Unit were obtained from the archive with the permission of the ethics committee and all files were examined in the archive. Only the authors examined the patient files and no files were taken outside. Each file was examined by two same authors.

In our hospital sedation protocols are performed by experienced anesthesiologists. Due to the retrospective nature of our study the authors had no intervention to the sedation protocols. We aimed to provide a safer environment for patients and healthcare personnel by retrospectively examining the peroperative and postoperative complications associated with sedation in pediatric patients taken in the MRI Unit of our tertiary hospital, and determining the necessary measures to reduce these complications.

Plan

The files of consecutive pediatric patients, who were taken in the MRI Unit of our hospital during a 6-month period, were retrospectively reviewed. A total of 319 patient files were accessed in a 6-month period. Parents of 14 patients did not consent to participate in the study, 46 patients were adult, 134 patients had missing data in their files and general anesthesia was administered to 3 patients during MRI (Figure 1). A total of 122 patients with physical status I-II-III according to the American Society of Anesthesiology (ASA) criteria were included in our study.

Patients who are between 3 months-16 years old with a parental consent to participate our study, are included. Exclusion criteria were; refusal to participate the study, missing data in patient files (Indicated below, see 'Data') and patients undergoing general anesthesia during MRI.

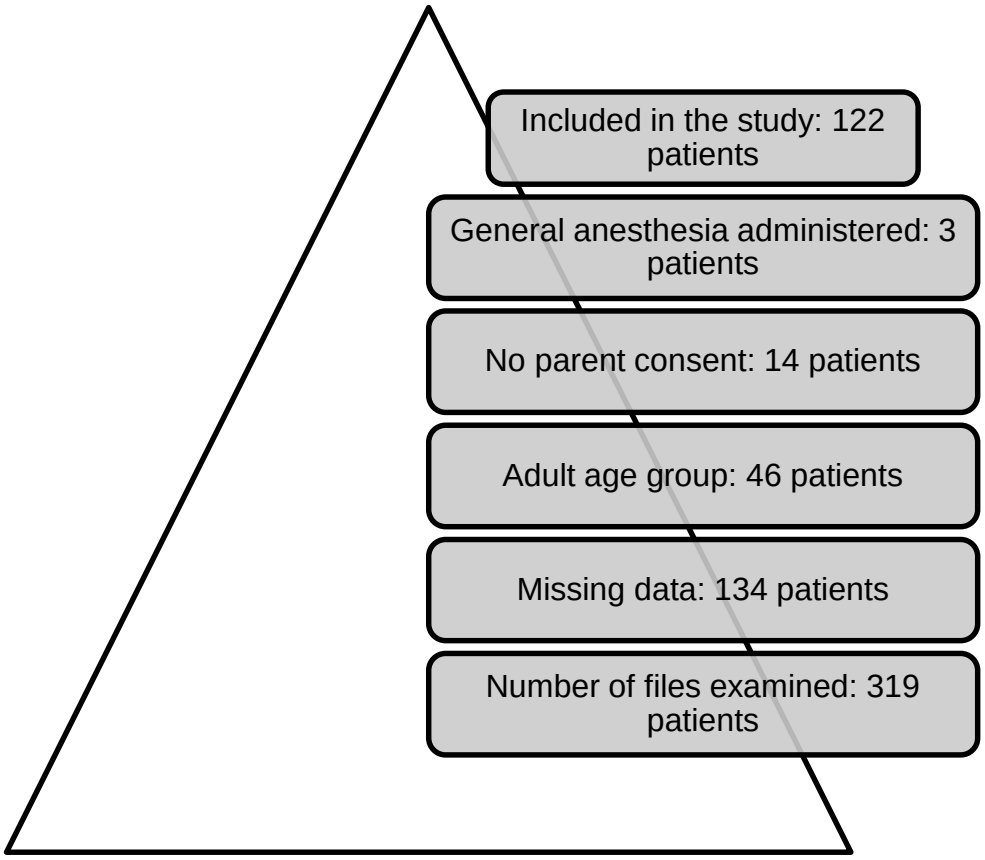

Figure 1. Patient data flow diagram

Procedure

The criteria examined in the study are as follows: gender, age, body weight, comorbid diseases, ASA scores, heart rate and spO2 values before induction, post-induction, maintenance and recovery, the amount of O_2 given during the procedure (l/min), recovery and sedation times, type of MRI, peroperative and postoperative complications during sedation and recovery and how to intervene in these complications, types and doses of anesthetic agents used during sedation and airway control. Since the peroperative and postoperative temperature measurement values could not be reached in the patient records, this parameter could not be evaluated.

A SpO2 value of <90% was defined as desaturation, and bradycardia[9] was defined as a heart rate of less

than 80 beats per minute in patients younger than 1 year and 60 beats per minute in patients older than 1 year. While the duration of sedation is defined as the time from the beginning of the sedation to the end of the examination; Recovery time was defined as the time from when the patient was transferred to the Post-Anesthesia Care Unit (PACU) until discharge from the PACU. Postoperative follow-up of all patients included in the study was done in the PACU, and then all patients were discharged home.

Statistical analysis

In the statistical analysis, 122 consecutive pediatric patients who were sedated by our anesthesia team in the MRI Unit of our hospital during a 6-month period were included. The data obtained were evaluated using the 23th version of the SPSS program. Frequency (percentage) and mean±standard deviation for diagnostic statistics; Mann Whitney U test for sedation and recovery times; The chi-square test was used for the incidence of complications. Pearson correlation test was used for the correlation between recovery and sedation time. The power analysis of the study was found to be 71%. Since it is a retrospective study, the number of samples could not be intervened. $p<0.05$ was considered significant.

RESULTS

Demographic data of the patients are given in Table 1. When these patients were examined in terms of MRI types, 6.29% had abdominal MRI, 41.95% had cranial MRI, 13.28% orbital MRI, 5.59% brachial plexus MRI, 11.88% ear MRI, 5.59% total spinal MRI and other types of MRI (pituitary, nasopharynx, etc.) were obtained for the rest. It was also observed that more than one area was included in the same session in some patients.

Table 1. Demographic data of pediatric patients

Variable		n (%)
Gender	Female	51 (41.8)
	Male	71 (58.2)
Age (mean 2.8±2.5) (min 3 months - max 16 years)	<1 year	19 (15.6)
	≥1 years	103 (84.4)
ASA score	I	67 (54,9)
	II	53 (43,4)
	III	2 (1,6)

N: number of patients; ASA: American Society of Anesthesiology

In the pre-anesthesia evaluations made before MRI; airway assessments could not be performed in 63% of patients due to age, inconsistency, and agitation. One patient had a cushingoid appearance due to long-term steroid use and a history of difficult intubation in previous anesthesia reports, and it was considered as a difficult airway.

Since all patients to be sedated came to the MRI Unit by opening vascular access by the department they were consulted, none of the patients were premedicated. Three anesthetic agents were used during induction. These are midazolam, propofol and ketamine. Midazolam was used in 96.7% (n=18), propofol in 99.2% (n=121) and ketamine in 4.9% (n=6) of the patients. In general, induction was provided to the patients as a combination of double or triple anesthetic agents.

The anesthetic agents used in induction or maintenance of the patients and their doses are given in Table 2. 118 patients received iv 0.1mg/kg (min-max; 0.02-1.1 mg/kg) midazolam. 2.1 mg/kg (min-max; 0.5-6.2mg/kg) propofol iv was used during induction in 120 patients. In 6 patients, ketamine was administered during induction, and the mean dose was determined as 0.6 mg/kg iv (min-max; 0.4-0.8 mg/kg). Propofol was used iv at a rate of 5.0 mg/kg/h (min-max; 3.0-10.0 mg/kg/h) for sedation maintenance in 121 patients. When examining whether there is any decrease in the doses of other anesthetic agents in patients using ketamine; midazolam dose ($p = 0.596$) and maintenance propofol dose ($p = 0.870$) did not decrease, but the dose of propofol used in induction decreased significantly ($p = 0.000$).

Table 2. Doses of anesthetic agents administered to patients during induction

	Number of patients (n)	Dose (mg/kg) (median (min-max))
Midazolam	118	0.1 (0.02-1.1)
Propofol	120	2.1 (0.5-6.2)
Ketamine	6	0.6 (0.4-0.8)

In the patients included in the study, O_2 (5.8±1.3 l/min) was administered via an O_2 mask to all patients during sedation. If we review the complications from the beginning of the sedation until the end of the procedure; no complications were observed in 93.4% of the patients. Desaturation was found in 6 patients, bradycardia and desaturation in 1

patient, and airway obstruction in 1 patient. After the procedure, the patients were taken to the PACU, monitored and followed closely to keep them under control and to ensure their recovery. No complications were observed in 97.5% of the patients during the recovery; desaturation developed in 2 patients and bradycardia in 1 patient. Comparison of patient groups with and without complications during sedation and recovery is given in Table 3. There was no significant relationship between the complications that occurred during sedation and during recovery (p=1.0).

Table 3. Comparison of complications developed during sedation and recovery

	Complication + (n)	Complication - (n)	p value
During sedation	8	114	1.0
During recovery	3	119	

(n, number of patients)

Oral airway was used in 8 patients and laringeal mask airway (LMA) was used in 1 patient to intervene in the complications. In the previous anesthesia reports of the patient who used LMA, it was reported that the patient had a difficult airway, and after desaturation during the procedure, ventilation with a balloon-mask could not be ventilated, and the patient was ventilated by inserting the LMA. During the procedure, it was connected to an MRI compatible anesthesia machine and manually ventilated, and the procedure was completed without any problems. At the end of the procedure, the LMA was removed and followed closely in the PACU, and no additional problems were encountered. In case of bradycardia developing in the patients, 0.01mg/kg iv atropine was administered; response was obtained and the heart rate reached normal values. There were no additional problems in the follow-up.

Depending on the examination performed and the general condition of the patient, sedation and recovery times varied. In our study, the average duration of sedation was found to be 29.4±9.2 minutes. It was found that the duration of sedation was prolonged in patients in whom more than one area was imaged. The mean recovery time was found to be 24±9.5 minutes. No correlation was found between sedation time and recovery time (p=0.099) (Figure 2). There was no relationship between the recovery period and the incidence of complications that developed during this period (p=0.299).

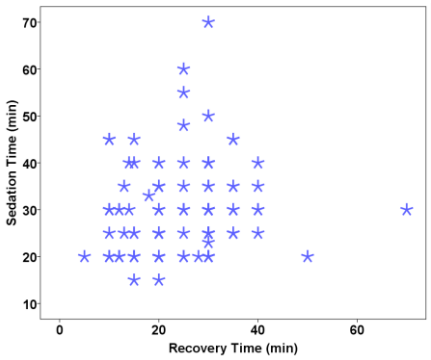

Figure 2. Correlation between recovery time and sedation time.

Pearson Correlation, r=0.150; p=0.099)
Each symbol represents a patient, bold symbols represents overlapping values. (min, minute)

DISCUSSION

In our study, the risk of developing complications during the sedation application of pediatric patients by the anesthesia team in the MRI Unit was found to be 6.6%. The most common complication was desaturation. In most of our patients, multiple drug combinations (midazolam, ketamine, propofol) were used. The dose of propofol used in induction and maintenance, together with the additional anesthetics used, was 2.1 mg/kg and 5 mg/kg/h, respectively.

Complications that may develop in NORA, which have been examined in studies to date, are as follows; death, hypothermia, aspiration of gastric contents, nausea-vomiting, desaturation and harms that the anesthesia team may be exposed to (such as waste inhalation anesthetics, exposure to radiation, exposure to electromagnetic field)[10]. Complications were found in 8 (6.6%) patients out of 122 patients included in our study; and the complications that we could obtain from the recordings were desaturation, bradycardia, and airway obstruction. It has been determined that these complications can be intervened with methods such as chin suspension, oral airway placement, emergency drug administration, LMA placement and shoulder roll placement. In our study, no deaths occurred and CPR was not required. It can be considered that the number of our patients is insufficient in terms of examining the types of complications; therefore, some complications encountered in other studies may not have been observed in our study.

From NORA applications; in a study in which 12030 patients in the age group of 21 years and younger were examined, in which esophagoduodenoscopy, colonoscopy or both were applied; it has been reported that patients aged ≤5 years have a higher incidence of developing complications compared to patients aged >5 years. Similarly, a higher incidence of complications was reported in patients with ASA ≥2[11]. In our study, the total number of patients who developed complications was 8. 7 (7/8) of the patients who developed complications were ≤5 years old; and 6 (6/8) were found to have ASA ≥2. It has been shown that the incidence of complications increases as the ASA score increases and the age decreases.

In a study in which pediatric patients were examined in terms of complications that may develop in NORA, no deaths were reported and CPR was applied in 1 patient. Desaturation lasting longer than 30 seconds was reported in 157 (1.57%) of 10000 patients[12]. In a similar study by Gozal et al., complications were reported at a rate of 1.7%; it was reported that most of the complications (86%) were desaturation[13]. Desaturation developed in 6 (6/122) patients in our study. Due to the retrospective nature of our study, data on desaturation times could not be reached.

In our study, for sedation applied in MRI; propofol, midazolam or ketamine were preferred. The physical condition of the patients and the presence of comorbid diseases were taken into account in the choice of anesthetic agent (eg, ketamine was not used in patients with increased intracranial or intraocular pressure). Short-acting anesthetic agents were preferred, as the patients were admitted with an outpatient procedure.

In the study of Usher et al., in which 100 patients were evaluated in terms of side effects and clinical symptoms, it was reported that pediatric patients were sedated for MRI and propofol was preferred as the anesthetic agent[14]. It was reported that no symptoms indicating airway obstruction were observed in a total of 93 patients. In patients who develop complications; the intervention was performed by placing a shoulder roll in one patient, using the oral airway in 4 patients, using the chin lift method in 2 patients, and taking the lateral position in 1 patient. The mean induction dose of propofol was 3.9 mg/kg (1.8-6.4 mg/kg), and the mean propofol infusion rate was 11.58 mg/kg/hour (150-250 mcg/kg/min). The potential to act during the procedure has been shown to be more likely at lower infusion doses (175 mcg/kg/min). The recovery time was also found to be 44 minutes on average[14]. In our study, during sedation; it has been observed that not propofol alone but combinations of double or triple anesthetic agents, including midazolam or ketamine, are used together. There are a total of 121 patients who used propofol. The mean dose of propofol during induction is 2.1 mg/kg (min-max; 0.5-6.25 mg/kg). During sedation maintenance, only propofol use was preferred. The average maintenance dose of propofol is 5.0 mg/kg/h (min-max; 5.0-10 mg/kg/h). The low dose of propofol used during induction and maintenance was thought to be due to the additional anesthetics used. The mean recovery time was found to be 24 minutes. The lower doses of propofol used in induction and maintenance in our study may have shortened the recovery time.

In the study of Demir et al., in which they applied the 'polyphase sedation' protocol in the computed tomography and MRI unit; pediatric patients were randomly divided into two groups; The effect of premedication with oral midazolam on the need for the dose of propofol used in induction, anxiety and parental satisfaction was investigated. It has been reported that the need for iv bolus propofol (1.36±1.11 mg/kg) for imaging decreased with premedication[15]. In our study, premedication was not applied to pediatric patients in the MRI Unit before the procedure. During induction, iv ketamine (0.6 mg/kg), propofol (2.1mg/kg), or midazolam (0.1mg/kg) were used. During maintenance, propofol was administered as a continuous infusion instead of an intermittent intravenous bolus. With continuous infusion, the patient was kept completely still during the procedure and no undesirable conditions were encountered that required repeating the examination.

In a retrospective study that included only diagnostic imaging modalities, in which sedation with propofol bolus and infusion was applied, patients were divided into two groups (patient groups treated with sedation for <1 hour and ≥1 hour). In both groups, the most common conditions requiring intervention were agitation and desaturation[16]. In our study, additional agents were used with propofol, depending on the clinical condition of the patient. Agitation was not observed in any of our patients, and we think that this is due to our use of multiple agents regimen.

In the multicenter study of Couloures et al. in which they examined 131751 pediatric patients, sedation

users were compared in terms of the incidence of complications. Complication rates were 7.6% (4.6-12.8%) in anesthesiologists, 7.8% (5.5-11.2) in emergency physicians, 9.6% (7.3-12.6%) in intensive care unit doctors, 12.4% (6.9-20.4%) in pediatricians and 10.2% (5.1%-18.3) in other specialties[8]. In the MRI Unit of our hospital, only anesthesiologists apply sedation to pediatric patients during the procedure. An experienced anesthesiologist and accompanying staff are familiar with the setting and the procedure. In our study, our complication rate was found to be 6.6%, similar to this study. No major complications were encountered.

NORA practitioners; should be experienced about the pharmacological properties of the drugs to be used, complications and advanced pediatric life support and airway management, management of complications and monitoring in specific areas such as NORA[17,18]. Our patients were sedated by an experienced anesthesiologist with the above-mentioned features. In addition, all patients were under the supervision of the anesthesiologists in the perioperative period. Any complications were intervened in a timely manner and all patients were discharged home. None of the patients' imaging procedures were canceled due to sedation failure and/or complications. We think that it is important for the sedation practitioner to have up-to-date knowledge and skills about NORA.

Our study has some limitations as it is a single-centered retrospective study. In this study, the underlying medical conditions and imaging indications may limit the applicability of the study results. Although the sedation practitioner during MRI was an experienced anesthetist in NORA, the sedation protocol could not be standardized due to the retrospective design. 134 patients' data in the files were missing, so total number of patients included in the study period is relatively small.

Multiple drug combinations (midazolam, ketamine, propofol) were used during sedation in pediatric patients in the MRI Unit, and the dose of propofol we used during maintenance was found to be lower than other studies in the literature. Also, the risk of developing complications was found to be lower. This may be because the need for the dose of propofol is reduced due to the additional anesthetics used. The incidence of complications can be reduced when the induction and maintenance dose of propofol is reduced by the use of additional anesthetic drugs.

As a conclusion, considering that the most common complications are desaturation and bradycardia, it should be highlighted that anesthesia applications during MRI in pediatric patients should be performed by experienced and trained teams.

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