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Intraoperative fluid management in pediatric patients using bioelectrical impedance analysis during oral surgery

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Keypoints

The transition of fluid may be studied by bioelectrical impedance analysis during general anesthesia. Pediatric patients became dehydrated conditions in spited of fluid administration, resulting in a reduced ICW during general anesthesia.

Abstract

Introduction

Fluid therapy is important for optimal outcomes after surgery. Fluid restriction has been recommended to reduce complications after major surgical procedures, although there are unknown about minor surgery. Conventional fluid therapy has been performed to correct preoperative dehydration and maintain body fluid levels. But, too much or too little fluid might be administered, because the degree of dehydration or fluid deficit is not measured. In this study, we investigated the transition of fluid by bioelectrical impedance analysis (BIA) during general anesthesia, retrospectively.

Methods

The patients were between 2 and 12 year-old, ASA-PS I, who underwent oral surgery under general anesthesia. We investigated patients' demographics, anesthesia time, operative time, fasting time and infusion volume. With respect to TBW, plasma fluid, interstitial fluid and ICW, we extracted the data from the induction of anesthesia to 3 hr later.

Results

Sixteen patients were suitable for this study. Patients were 5.7 ± 2.1 year-old. All patients' fasting time (average) was over 6 hours. There were no perioperatively respiratory and cardiac complications. Anesthesia time was 257.2 ± 26.5 min. Transfusion volume was 412.8 ± 98.4 (ml). Urine catheter was not inserted during general anesthesia. Between induction of anesthesia and 3 hr later, both plasma fluid and interstitial fluid were significantly higher compared to those in induction of anesthesia ($p=0.02$). ICW was lower to that of in induction of anesthesia ($p= 0.20$).

Conclusions

Pediatric patients became dehydrated conditions in spited of fluid administration, resulting in a reduced ICW during general anesthesia.

Keywords: Intraoperative fluid management; pediatric patients; bioelectrical impedance; oral surgery.

Introduction

Fluid therapy is important for optimal outcomes after surgery [1-5]. Recently, fluid restriction has been recommended to reduce complications after major surgical procedures, although there are unknown about minor surgery [1, 4, 5]. The outcomes of volume overload were associated with postoperative recovery [6].

The concept of Enhanced Recovery After Surgery (ERAS) has altered preoperative and postoperative care, particularly for major surgery [5, 7]. ERAS also recommend near-zero fluid balance as well as salt and water restriction to improve postoperative outcomes. However, in Japan, most institutions have not yet established ERAS protocols [8]. According to current guidelines, preoperative oral intake of clear fluids can be safely consumed up to 2 hr before surgery, and a light meal may be consumed up to 6 hr preoperatively [2, 7]. However, conventional fasting times are frequently longer than the expected 6-10 hr [9]. Especially, pediatric patients might be more vulnerable to dehydration because they have a relatively greater ration of total body water (TBW) in body weight compared to adults. Conventional fluid therapy has been performed to correct preoperative dehydration and maintain body fluid levels during general anesthesia. But, too much or too little fluid might be administered, because the actual degree of dehydration or fluid deficit is not measured during general anesthesia.

Assessment tools for determining body fluid parameters are currently available [9-12]. Especially, bioelectrical impedance analysis (BIA) is a simple and noninvasive method for evaluating parameters such as body composition in patients during general anesthesia. In our clinical practice, BIA (BioScan 920-II, MP Japan Co., Ltd., Japan) has been performed due to assessment of transition of body water distribution during general anesthesia. In short surgery, urine catheter has not been inserted. Therefore, the monitoring of the hemodynamics change such as blood pressure and heart rate has been used to assess body fluid with limited accuracy and reliability during general anesthesia.

The prediction of the body composition or hydration status is especially important for appropriate administration of fluid to pediatric patients during general anesthesia.

We hypothesized that preoperative dehydration after overnight fasting affects crystalloid redistribution. In this study, we investigated the transition of fluid such as, intracellular water (ICW), plasma fluid and interstitial fluid by BIA during general anesthesia in pediatric patients undergoing oral surgery, retrospectively.

Materials and methods

The Ethic Review Board of Kyushu University Hospital approved this retrospective study (Approval No.29-122). The study period was from February 2016 until April 2017. The patients were between 2 and 12 year-old, ASA-PS I, who underwent dental procedure under general anesthesia in Kyushu University Hospital. Patients with cardiovascular, respiratory or neurological abnormalities, as well as those with renal disease, were excluded from the study.

We reviewed the anesthesia records and investigated patients' demographics (age, gender, height, weight, BMI), anesthesia time, operative time, fasting time and infusion volume.

For preoperative fasting, oral intake of a light meal was permissible up to midnight, and clear fluid up to 6:00 AM. Patients who were scheduled for induction of anesthesia starting at 8:15 AM (the first case on the operative day) did not receive preoperative fluid loading. No patients were premedicated. Anesthesia was induced with inhalation of sevoflurane in oxygen and/or N_2O after the start of noninvasive monitoring for SpO_2. After the loss of consciousness, monitoring of ECG, BP and HR were started. The patient's body fluids were measured using BIA during general anesthesia. Fentanyl, atropine and rocuronium were administered after peripheral intravenous access was obtained. After intubation, anesthesia was maintained with sevoflurane or isoflurane in air and oxygen. In addition, fentanyl was administered for analgesia in all cases. After surgery, all anesthetics were turned off with the last stimulus techniques such as gastric tube and suction into trachea. After spontaneous regular respiration and upper airway patency were observed, we could smoothly extubate. Their respiratory and hemodynamic conditions were stable, and they discharged to the patient room.

When calculating surgical fluid-loss estimates, duration and patient body weight were taken into account. Patients were administered crystalloid loading at 10 mL/kg/h from induction of anesthesia until starting the surgical procedure, and 1 to 3 mL/kg/h during surgery.

With respect to TBW, plasma fluid, interstitial fluid and ICW, we extracted the data from the induction of anesthesia to 3 hr later. Body compositions were measured using a BIA.

This device uses tetrapolar electrodes placed on hands and feet, including the extremity with the intravenous line placed, to obtain readings. It allows the calculation of body composition and volumes (plasma fluid, interstitial fluid and ICW) by means of an electric current passing through the body.

The primary outcome was the change of ICW, plasma fluid or interstitial fluid during general anesthesia.

For statistical analysis, the demographic data were compared using the unpaired t-test with a p-value of 0.05 regarded as significant.

All values are expressed as mean ± standard deviation (SD) or number of patients (n).

Results

Sixteen patients were suitable for this study. The surgical procedures in this study were conservative dentistry treatment, intraoral tumor removal, cyst removal or extraction of teeth.

There were no perioperatively respiratory and cardiac complications. Fasting time were solids (766.9 ± 42.4 min) and for clear fluids (412.8 ± 98.4 min). Operative time was within 3 hr for all cases. Concerning the patients' background on the anesthesia records were shown Table 1.

Fentanyl and remifentanil were administered in all case. Urine catheter was not inserted during general anesthesia. In two time zones (induction of anesthesia and 3 hrs later), both plasma fluid (1.2 ± 0.3 L) and interstitial fluid (4.1 ± 0.9 L) were significantly higher compared to those(0.9 ± 0.2 L, 3.3 ± 0.8 L) in induction of anesthesia (p=0.02). The ICW (4.6 ± 1.3 L) was significantly lower to that (5.3 ± 1.6 L) of in induction of anesthesia (p= 0.20).

Age (year)	5.7 ± 2.1
Gender (Male/ Female)	10 / 6
Height (cm)	104.9 ± 10.2
Weight (kg)	16.7 ± 3.0
BMI (m^2/kg)	15.2 ± 2.1
Anesthesia time (min)	257.2 ± 26.5
Operative time (min)	183.6 ± 28.2
Fentanyl (μg)	61.3 ± 27.9
Transfusion volume (ml)	412.8 ± 98.4

Table 1. Clinical characteristics and anesthetic data on patients (n=16). Values are means ± SD or number of patients.

Discussion

We have demonstrated fluid change leading to decrease ICW using BIA during general anesthesia.

Under normal circumstances, the pediatric fluid volume condition before induction of general anesthesia are unknown. Fluid administration provides to correct the preexisting fluid deficit and to compensate for perioperative fluid shifts between ICW and ECW. Expansion of the intravascular compartment of ECW might be beneficial. Because, it could be compensate for the vasodilatory effects of anesthetic agents and dehydration. However, the exact target fluid therapy might remain unclear, and adequate targets cannot be measured in clinical routine. In minor surgery, there is no concern about fluid loss of fluid shift, which can be associated with major surgery [4, 5].

Many fasting guidelines allow clear fluid intake up to 2 hours before surgery [2, 7]. In this study, there might exist a fluid deficit secondary to the preoperative fasting guidelines. Intraoperative fluid shifts might be small, and the risk of organ dysfunction might be low. Due to short procedure, we thought it was not necessary to insert urine catheter for measuring urine volume. However, fasting times in all patients were actually frequently longer than the expected 2-3 hrs. The preoperatively fasted patients might be hypovolemic conditions due to ongoing perspiration and urinary output [1, 14].

Total body water in pediatric patients exists in ECW and ICW. ICW represents approximately two thirds of TBW, ECW represents approximately one third of TBW [15]. Among all of these compartments there is a constant redistribution of free water that is dictated by ionic and osmotic pressure. Prolonged fasting time and fluid administration without urine catheter might lead to the change of body composition during general anesthesia. It was reported that Jacob et al. found that a prolonged fasting period is unlikely to affect cardiopulmonary function and cause hypovolemia in healthy adult patients [16]. However, in this study, loss of ICW occurred. ICW declined due to preoperative fasting and low fluid therapy during general anesthesia in this study, although hemodynamic change was stable and postoperative no complications.

Urinary catheters are usually used for longer surgical procedures to allow monitoring urinary output and guiding fluid therapy. Currently, there is no standard protocol for the implementation and maintenance of indwelling catheters for minor surgery. But, we might pay attention to monitor urinary output with urinary catheter for minor surgery.

The limitations of this study include retrospective design and the restriction of BIA data of intraoperative patients. In addition, due to the small sampling size, inaccurate fasting time and volume, further study of patients undergoing oral surgery might help importance of BIA values.

Conclusion

Pediatric patients became dehydrated conditions in spited of fluid administration, resulting in a reduced ICW during general anesthesia.

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