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SCIENTIFIC ARTICLE

Risk Factors for Perioperative Complications in Endoscopic Surgery with Irrigation

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Abstract

Background and objectives: Currently, endoscopic medicine is being increasingly used, albeit not without risks. Therefore, this study evaluated the factors associated with perioperative complications in endoscopic surgery with intraoperative irrigation.

Method: A cohort study of six months duration. Patients aged ≥ 18 years undergoing endoscopic surgery with the use of irrigation fluids during the intraoperative period were included. Exclusion criteria were: use of diuretics, kidney failure, cognitive impairment, hyponatremia prior to surgery, pregnancy, and critically ill. The patients who presented with or without complications during the perioperative period were allocated into two groups. Complications evaluated were related to neurological, cardiovascular and renal changes, and perioperative bleeding.

Results: In total, 181 patients were enrolled and 39 excluded; therefore, 142 patients met the study criteria. Patients with complications amounted to 21.8%, with higher prevalence in endoscopic prostate surgery, followed by hysteroscopy, bladder, knee, and shoulder arthroscopy (58.1%, 36.9%, 19.4%, 3.8%, 3.2% respectively). When comparing both groups, we found association with complications in univariate analysis: age, sex, smoking, heart disease, ASA, serum sodium at the end of surgery, total irrigation fluid administered, TURP, and hysteroscopy. However, in multiple regression analysis for complications, only age (OR = 1.048), serum sodium (OR = 0.962), and volume of irrigation fluid administered during surgery (OR = 1.001) were independent variables.

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Conclusion: The incidence of serious complications in endoscopic surgeries is high. Serum sodium at the end of the operation, amount of irrigation fluid, and age were strong independent factors associated with the problem. Thus, these factors must be taken into account in these surgeries.

Introduction

Endoscopic surgical procedures have been increasingly used in current medical practice due to the smaller incision, less aggression of body structures, and better postoperative recovery. In some types of endoscopic surgery, such as transurethral prostatectomy or hysteroscopic procedures, continuous irrigation with hypotonic fluids is used to dilate the operating field and allow better visualization of structures addressed while removing debris and blood, which facilitates the surgical intervention. However, it is not without risks. One of the main problems related to this type of surgery are electrolyte, cardiovascular and neurological disorders [1].

The most important factor associated with the development of complications resulting from hypotonic irrigating fluid in endoscopic procedures is the irrigating fluid absorption through the vascular bed opening during surgery, particularly if the irrigation pressure is too high [2]. Other factors influencing the onset of complications are associated with the fluid used and type and duration of surgery [3,4]. The most frequent electrolytic problem in these patients [5] is hyponatremia, defined as serum sodium (Na +) concentration less than or equal to 135 mEq.L^{-1} [6,7]. However, fluid overload followed by pulmonary congestion, neurological disorders of varying magnitude, and cardiovascular collapse may occur [7].

Complications during endoscopic surgery is associated with a number of unfavorable outcomes, such as the need for intensive care unit (ICU) admission, prolonged hospitalization, higher hospital costs, and mortality [8-11].

Despite previous reports, there are few national studies assessing perioperative clinical complications in patients undergoing endoscopic procedures requiring irrigation with hypotonic fluids. Thus, this study aims to assess the incidence, predictive factors, and complications in patients undergoing these procedures.

Method

After the institutional Ethics Committee approval, the research team screened consecutive patients undergoing endoscopic operations using irrigation fluids. In order to reduce selection bias in the study, data from the medical records of patients undergoing transurethral resection of the prostate (TURP), transurethral resection of the bladder (TURB), knee arthroplasty, shoulder arthroplasty, and hysteroscopy during the study period (6 months) were collected. Given the observational and epidemiological nature of the study, with data analysis of medical records, the institutional Ethics Committee waived written informed consent.

Inclusion criteria were patients aged 18 years or older, undergoing endoscopic operations with irrigation fluids. Exclusion criteria were patients with renal insufficiency, on diuretics, history of cognitive disorders, hyponatremia prior to surgery, pregnancy, and those with low life expectancy due to the previous condition or tumors without expectation of curative treatment.

The data collection form was composed of three parts: 1) preoperative evaluation; 2) intraoperative assessment; 3) postoperative outcome evaluation. Preoperative evaluation included the following variables: sex, age, weight, height, ethnicity, ASA physical status, smoking, heart disease, arrhythmias, hypertension, and asthma. Intraoperative assessment included: duration of surgery; plasma sodium concentration at the beginning and end of the operation; type of irrigation fluid used during surgery (0.9% sodium chloride, mannitol, or glycine solutions); volume of irrigation fluid infused; height of the irrigation fluid container in relation to the patient's mid-axillary line (often measured for irrigation pressure monitoring); type of fluid used for intravenous hydration during surgery (sodium 0.9% chloride solution, lactated Ringer solution, or 6% hydroxyethyl starch); intraoperative volume replacement; type of anesthesia used and type of surgery performed. The third part of the questionnaire consisted of data from clinical and postoperative outcomes. We recorded total time of hospital stay, need for intensive care after surgery, and perioperative complications, such as decreased level of consciousness, arrhythmia, bleeding, seizures, acute renal failure, and circulatory shock.

According to the anesthesiology service protocol, patients were monitored with cardioscopy, pulse oximetry, capnography, and noninvasive blood pressure. During surgery, the anesthesiologist in charge chose both the anesthetic technique and anesthetics. After induction, temperature and urine output were also monitored. Adjusted mechanical ventilation according to the anesthesiologist in charge, usually at a tidal volume between 8 and 10 mL.kg^{-1}, and respiratory frequency between 10 and 14 bpm to maintain end-tidal carbon dioxide ($EtCO_2$) between 35 and 40 mm Hg. Positive end-expiratory pressure (PEEP) was applied, at the anesthesiologist's discretion, between 3 and 5 cm H_2O. A blood sample is routinely collected at the beginning and end of the procedure to assess metabolic changes possibly developed by the patient as a result of surgery. The presence of arrhythmias observed during the intraoperative period was assessed from the anesthesia records. For such cases a 12-lead electrocardiogram is part of the postoperative care routine in patients with arrhythmias during the intraoperative period.

Blood components and products were used when necessary, at the discretion of the anesthesiologist. After surgery, patients were transferred to the post anesthesia care unit (PACU) or ICU, according to the surgical team indication. The investigators had no influence on patients' treatment.

Statistical analysis

Collected data were entered into an electronic database (Microsoft Excel). We performed statistical analysis using SPSS 17.0 (SPSS Inc., Chicago, Illinois, USA). In order to analyze the incidence and risk factors for development of complications, we allocated patients into two groups: with and without complications. Patients assigned to the group with complications were those who presented with decreased level of consciousness or seizure, arrhythmias, congestive acute renal failure (diuresis < 0.5 $mL.kg^{-1}.h^{-1}$ or creatinine > 30%), hypertension or hypotension (change in mean arterial pressure higher or lower than 30% of baseline value), and uncontrollable bleeding (sharp decrease in hemoglobin by more than two points). Such complications and the definition of hyponatremia are reported in previous studies [6,12,13,14].

In the first phase of the study, we assessed preoperative and intraoperative variables for developing complications using the Kolmogorov-Smirnov test for distribution of quantitative, continuous or discrete variables. We expressed categorical variables by calculating the frequencies and percentages. We expressed quantitative variables using measures of central tendency and dispersion. Initially, we described the demographic, clinical, and physiological characteristics of patients included in the study.

To test whether there was any relationship between quantitative variables normally distributed and the presence of complications, we used the Student's t-test for unpaired variables normally distributed. Mann-Whitney test was used for quantitative variables not normally distributed. The association between categorical variables and the outcome variable was tested using the chi-square test. Regarding nonparametric variables, we performed a Monte Carlo correction per 1,000 patients. Finally, logistic regression (stepwise) was applied for variables strongly associated ($p \leq 0.1$) with complications in univariate analysis, in order to avoid confounding factors and find independent variables related to the problem. All statistical tests were two-tailed, and the significance level used was 0.05.

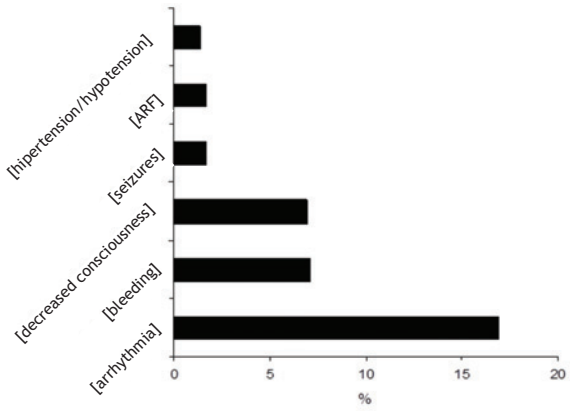

Figure 1 – Percentage of Complications.

Results

In total, 181 patients were enrolled and 39 excluded; therefore, 142 patients met the study criteria. Patients with complications amounted to 21.8%. The main complications were cardiovascular (Figure 1) and, when compared to demographic data, showed correlation with age, sex, ASA physical status, smoking, and heart disease (Table 1).

Table 1 – Comparison of Groups Regarding Patients' Baseline Characteristics.

Variables	Without complications (n = 111)	With complications (n = 31)	P
Age (years)	60.8 ± 12.8	69.8 ± 12.6	0.001
Male (%)	53.2	87.1	0.001
Weight (kg)	75.31 ± 13.740	75.35 ± 12.233	0.98
Height (cm)	165.9 ± 9.3	167.9 ± 7.5	0.27
White (%)	70.3	77.7	0.38
ASA II (%)	66.7	71.1	0.01
Comorbidities (%)			
Neoplasm	18.0	21.6	0.60
Smoking	3.6	16.1	0.02
Alcoholism	2.7	9.7	0.12
Heart disease	0.9	16.1	0.02
Hypertension	37.8	54.8	1.00
Asthma	0.9	3.2	0.39
Diabetes	19.8	12.9	0.44

Table 2 – Comparison of Groups Regarding Patients' Postoperative Characteristics.

Variables	With complications (n = 111)	Without complications (n = 31)	p
Sodium: beginning of surgery (mEq.L^{-1})	141.0 ± 2.5	140.7± 1.8	0.54
Sodium: end of surgery (mEq.L^{-1})	139.3 ±3.6	135.4 ± 8.5	0.000
Irrigation fluid (%)			
Glycine	49.5	45.2	0.69
Mannitol	30.6	38.7	0.51
0.9% saline solution	18.9	16.1	0.80
Total fluid administered (mL)	7000 (3000- 12000)	12000 (6250-18000)	0.001
Irrigation height in relation to the patient (cm)	74.45 ± 11.53	77.26 ± 11.927	0.23
Fluid hydration (%)			
Saline solution 0,9%	63.1	80.6	0.08
Ringer lactate	55.9	54.8	1.00
Synthetic colloid (starch)	0	3.2	0.21
Total fluid administered (mL)	1000 (500-1.500)	1000 (625-1.500)	0.39
Anesthesia (%)			
Spinal anesthesia	87.4	87.1	1
General	11.7	9.7	1
Sedation	56.8	48.4	0.42
Surgeries (%)			
TURP	27.9	58.1	0.003
TURB transurethral resection of the bladder	22.5	19.4	0.81
Hysteroscopy	12.9	36.9	0.01
Knee arthroscopy	5.2	3.8	1
Shoulder arthroscopy	5.4	3.2	0.70
Duration of surgery (min)	60 (45-90)	75 (60-120)	0.13
Days of hospitalization	1.9 ± 0.8	3.0 ± 1.5	0.000
ICU admission (%)	0	22.6	0.000

TURP: transurethral resection of the prostate; TURB: transurethral resection of the bladder; ICU: intensive care unit.

Table 3 - Regression of Factors Associated with Complications.

Variables	p	OR	95% CI
Age (years)	0.029	1.048	1.005-1.093
Sodium: end of surgery (mEq.L^{-1})	0.000	0.962	0.942-0.982
Total fluid administered (mL)	0.006	1.001	1.001-1.002

OR: odds ratio; 95% CI, 95% confidence interval.

Table 4 - Sodium Disorder Complications.

Variables	Normonatremia (n = 116)	Hyponatremia (n = 26)	p
Hospital stay (days)	2 ± 0.9	2.6 ± 1.6	0.02
ICU admission (%)	2.6	15.4	0.02
Postoperative complications (%)	18.4	38.5	0.03
Decreased level of consciousness	1.7	19.2	0.001
Arrhythmia	12.9	34.6	0.01
Bleeding	4.4	19.2	0.02
Seizure	0.0	3.8	0.04
Acute renal failure	0.0	3.8	0.04
Circulatory shock	0.9	3.8	0.33

Hyponatremia = Na+ ≤ 135 mEq.L^{-1}; ICU: intensive care unit.

The mean value of serum sodium at the beginning and end of all surgeries was 140.9 ± 2.4 mEq.L^{-1} and 138.4 ± 5.3 mEq.L^{-1}, respectively. There was a higher incidence of complications in TURP, followed by hysteroscopy, TURB, and knee and shoulder arthroscopy (53.1%, 36.9%, 19.4%, 3.8%, and 3.2% respectively). There was also a significant association between complications and serum sodium at the end of surgery ($p < 0.001$), TURP surgeries ($p = 0.003$), hysteroscopy ($p = 0.01$), and in patients who received large amount of irrigation fluids during the intraoperative period ($p = 0.001$). Moreover, patients with complications evolved with longer hospital stay ($p < 0.001$) and greater need for ICU admission ($p < 0.001$) (Table 2).

However, in the logistic regression (stepwise) for variables associated with complications in univariate analysis (age, sex, alcoholism, smoking, heart disease, ASA, serum sodium at the end of surgery, total irrigation fluid administered, TURP, hysteroscopy), only age, serum sodium at the end of surgery, and volume of fluids administered intraoperatively were independent variables related to perioperative complications (Table 3).

Interestingly, patients with hyponatremia at the end of surgery (sodium < 136 mEq.L^{-1}) had worse postoperative outcome; i.e., higher incidence of decreased level of consciousness at the end of surgery ($p = 0.001$); and 3.8% of hyponatremic patients had seizures ($p = 0.04$), greater incidence of arrhythmias at the end of surgery ($p = 0.01$), increased bleeding ($p = 0.02$), and acute renal failure ($p = 0.04$), in addition to longer hospital stay ($p = 0.02$) and need for ICU admission ($p = 0.02$). However, no patient died in the hospital (Table 4).

Discussion

This study is one of the few in literature correlating perioperative complications with all types of endoscopic surgeries using intraoperative irrigation fluid and draws attention to the high incidence of problems during these surgeries.

In this study, we observed the occurrence of complications in 21.8% of patients. Such complications alone may cause serious problems and demonstrate that this type of surgery requires great care, as these complications are associated with serious water intoxication syndrome problems. Although clinical complications are often depreciated in this type of surgery, the incidence of water intoxication syndrome is estimated between 1% and 8%, with a mortality rate between 0.2 and 0.8% [1,2].

In the present study, we also found a higher incidence of cardiovascular problems, but respiratory, neurological, gastrointestinal, and kidney repercussions are not uncommon, witch are in agreement with literature data [15].

Among the comorbidities associated with this syndrome, smoking seems to be the only independent risk factor reported in literature as being related to the absorption of large amounts of fluids. There is no difference in the incidence between patients with prostate cancer and benign prostatic hyperplasia [1]. On the other hand, patients in the present study showed statistically significant differences between smoking, heart disease, and complications, but the same association did not occur in the multiple regression analysis.

Moreover, resection time, hydrostatic pressure of the irrigation fluid, number of venous sinuses open, in addition to venous pressure and blood loss are risk factors related to the procedure. Although the operating time and blood loss are known risk factors, it is difficult to predict the amount of fluid absorbed systemically from these variables [15]. Thus, there was no correlation between complications and these variables.

This fact may be explained by the surgical time recommended for the procedure, which is up to 60 minutes. In this study, the median surgical time was 60 minutes, as after that time an exponential increase in water absorption occurs, particularly after 90 minutes of surgery [15].

Furthermore, it is recognized that the hydrostatic pressure of the irrigation fluid interferes with the development of complications. The height of the irrigating fluid bag is closely related to hydrostatic pressure [16]. Thus, keeping the height of the irrigating fluid bag up to 60 cm from the left atrium is recommended, although there is one study [15] reporting that there is no relationship between this height and fluid absorption. The same could be demonstrated in the current study, in which the height was about 75 cm, without correlation with incidence of problems.

Likewise, the types of irrigation fluid contribute to specific symptomatology, both due to the variety of osmolality and composition characteristics [2].

Distilled water was for many years the main irrigation fluid used because it is inert, non-electrolytic, and has little influence on the visibility of the surgeon [2,15]. Currently, it has only historical value and is no longer used, so it was not administered to any patient in our study.

Although isotonic saline solution rarely causes cerebral edema [17], there are reports of hyperchloremic acidosis after its use, especially combined as intravenous hydration fluid in the intraoperative period [18]. There was low incidence of complications with this solution in the present study.

Glycine is primarily metabolized in the liver with ammonia formation, which is quite neurotoxic and may lead to cerebral depression and coma. Because it is an inhibitory neurotransmitter of the central nervous system, it may exacerbate the glutaminergic pathway and lead to seizures [7]. There was a high incidence of decreased consciousness and seizures, which may be a result of the use of this fluid. However, its correlation with our findings was difficult.

Regarding the type of endoscopic operation, the presence of complications was higher in prostatic surgeries and hysteroscopy. This finding may be explained by the fact that prostatic surgery presents major bleeding and, therefore, venous exposure. Other surgeries have little

bleeding and few reports in literature [4,17], but the type of surgery in this sample was not a strong variable associated with complications.

On the other hand, we noted that the infused volume, age, and serum sodium at the end of surgery seem to influence the incidence of problems in these surgeries and are closely related to the development of complications.

Studies have shown that the volume of fluid infused is a determinant factor for complications [15,19], as well as age. This is true not only in endoscopic surgeries [1] but in other surgeries [20,21] due to lack of fluid reserve that these patients may have. Thus, great care must be taken with elderly patients who undergo this type of procedure and when the volume of fluid irrigation is exorbitant.

Regarding sodium, fluid absorption can be coarsely measured by serial measurements of serum sodium. However, the finding of hyponatremia may not necessarily correspond to the water intoxication process [7]. Thus, the measurement of serum sodium alone is not a good indicator of this condition. However, this study demonstrated that hyponatremia in this type of operation has a direct correlation with other serious complications, and serum sodium measurement is relevant for the early detection of patients who will experience worse outcome.

Sodium is the main determinant of plasma osmolality and the most important extracellular cation, with normal concentration ranging from 135 to 145 $mEq.L^{-1}$. Change in concentration may not necessarily be a disturbance of sodium balance, but a change in the water balance [9,13,14].

Hyponatremia is the most common electrolyte disorder in patients undergoing endoscopic procedures with the use of irrigation fluids and hospitalized patients in general [5]. It may be defined as serum sodium concentration (Na+) below the lower normal limit. In most laboratories, this means Na+ < 135 $mEq.L^{-1}$, but the cut-off point Na+ < 136 $mEq.L^{-1}$ is also widely used [6]. The presence of hyponatremia is associated with a number of adverse outcomes, such as ICU admission, prolonged hospital stay, increased cost, and mortality [8,9].

The etiology of hyponatremia occurring in endoscopic surgery using irrigation fluid is hypotonic (osmolality < 280 $mosm.L^{-1}$) and results from large amounts of free water ingestion or accumulation above the renal excretion capacity [2,15].

Thus, although the diagnosis of complications in endoscopic surgery is unclear [7], it is important to identify the risk factors, pathophysiology and, as mentioned before, especially age, volume of irrigation fluid used, lower sodium value at the end of surgery, and signs and symptoms. These findings may lead to better therapeutic and anesthetic management in the perioperative period.

This study may be questioned by the sample size. This does not invalidate the finding since we try to correct the number by using the Monte Carlo statistical method adjusted per 1,000 patients. Second, the study observational nature has limitations inherent to the method. Thus, further studies with larger amplitude are needed to confirm these findings.

Thus, the incidence of complications in endoscopic procedures with irrigation is high. Serum sodium at the end of surgery, irrigation fluid volume, and age were strong independent factors associated with the problem.

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