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Case report

Fluid overload during operative hysteroscopy for metroplasty: A case report

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Abstract: Background: Hysteroscopic surgery represents a minimally invasive approach to the diagnosis and treatment of intrauterine pathologies. A distension fluid is required to provide visualization and hemostasis of the operative field. The use of a bipolar resectoscope enables the usage of electrolyte solutions, averting dilutional hyponatremia. However, fluid overload that can develop after the absorption of a sufficient amount of the irrigation medium is a complication to be feared. **Case presentation:** We report a case of a 23-year-old female patient who developed acute symptomatic fluid overload and pulmonary edema without dilutional hyponatremia (140 mmol/L) secondary to hysteroscopic transcervical endometrial resection (TCER) for a uterine septum, where the distending medium was saline solution 0.9%. **Conclusions:** Several precautions could be implemented to reduce the risk of fluid overload induced by the absorption of distention fluid. Namely, reducing the operative time, the flow, the total volume infused, the intrauterine pressure and strictly monitoring the absorbed volume. The instrumentation should support visual and auditory alarms. Moreover, all staff members should be acquainted with the clinical presentation and management, which mainly revolves around early identification. Therefore, regular simulated cases, to sharpen pathology-related knowledge and teamwork, should become standard practice.

Keywords: intravasation; TURP syndrome; gynecological surgery; dyselectrolemia

1. Case report

A 23-year-old woman was scheduled for a hysteroscopic transcervical endometrial resection (TCER) for a uterine septum, during the assisted fertility program. Her past medical history was unremarkable, except for seasonal pollen allergies and a previous miscarriage.

The anesthesia plan consisted of spontaneous breathing procedural sedation with an initial fentanyl bolus followed by target-controlled infusion (TCI) of propofol.

For surgical hysteroscopy, the Storz Hamou® Endomat® rolling pump was used coupled with a standard bipolar 26 French resectoscope. This system allows continuous flow at a determined pressure of a distending fluid. In this case, 15 liters of 0.9% saline solution were pumped during the procedure. The pressure was constantly in the safety range (around 50 mmHg). Due to a leakage in the aspirating limb, the difference between inflow and outflow volumes could not be estimated.

From the first minutes, the hysteroscopy was challenging because of poor visualization due to bleeding.

Ten minutes into the procedure, the anesthesia provider noticed progressive generalized swelling and a diffuse red rash. Suspecting an allergic etiology, 10 mg of chlorphenamine and 200 mg of hydrocortisone were administered. On lung auscultation, crackles and wheezing were present. Bag mask ventilation was initiated with a FiO_2 of 100% and a PEEP of 10 cmH_2O. Four puffs (400 mcg) of salbutamol were administered. Surgeons were asked to interrupt the procedure, however, due to ongoing hemorrhage.

Progressively, the mean arterial pressure dropped below 65 mmHg and oxygen saturation (SO_2%) reached a nadir of 59%. Therefore, adrenaline was administered initially via subcutaneous injection, then intravenous infusion was initiated. Moreover, the EKG monitor showed a pattern of ST depression. In the following 10 minutes, Kerley B lines appeared on lung echography, accompanied by pink frothy sputum, suggesting a picture of acute pulmonary edema. For this reason, 10 mg of morphine was administered intravenously. A situation of fluid intravasation and consequent volume overload was now the main suspect.

The arterial air blood gas analysis further sustained the latest hypothesis: pH of 7.05, pCO_2 61 mmHg, PO_2 47 mmHg, Na^+ 140 mmol/L, K^+ 2.6 mmol/L, Cl^- 120 mmol/L, HCO_3^- 13.7 mmol/L, Hb 10.8 g/dL (Table 1).

The procedure was stopped due to successful hemorrhagic control. Furthermore, the critical care team performed a rapid sequence intubation initiating mechanical ventilation. The ventilatory settings were: FiO_2 of 100%, tidal volume of 6 ml/kg and a respiratory frequency of 15/min. A positive end-expiratory pressure (PEEP) of 10 cmH_2O was set following toilette bronchoscopy and recruitment maneuvers. A bolus of 40 mg of furosemide was administered.

At the end of the procedure, the patient was transferred to the post-operatory intensive care unit (ICU), where organ support was granted: Vasopressors, ventilation and sedation were continued.

Hypokalemia was corrected by intravenous KCl and hypocalcemia was corrected by $CaCl_2$.

The response to the treatment was sustained diuresis. Subsequently, gradual amelioration of the respiratory indices. Great attention was kept for maintaining euvolemia to balance the profuse urinary output.

During the ICU stay, she remained stable with a heavily negative fluid balance (−7 Liters) on the first two days of admission and −1.7 L on the third and last day.

She was progressively removed from vasopressors, mechanical ventilation and all organ support. Stable and with no deficits of any sort, she was discharged to the gynecological ward on the third day after admission to the post-operatory ICU.

Informed consent was waived since it presents a life-threatening emergency with inadequate time to obtain consent and no patient identity is revealed. Ethics approval was not required for this case report.

Table 1. Blood gas analyses at different time-points. The first column shows the arterial blood gas parameters at the onset of the resuscitation. The second column shows the same information 1 hour after the beginning of resuscitation. The third column shows the improvement in the arterial blood gas values on the evening of the same day. The final column portrays the values within the physiological range at time of discharge.

	03/02/2022 9:33	03/02/2022 9:54	03/02/2022 21:00	05/02/2022 10:10
pH	7.05	7.19	7.39	7.41
pCO_2 (mmHg)	61	71	40	39
PO_2 (mmHg)	47	76	246	99
Na^+ (mmol/L)	140	146	144	137
K^+ (mmol/L)	2.6	2.2	3.0	3.7
Cl^- (mmol/L)	120	118	111	107
Ca^{2+} (mmol/L)	0.90	0.81	1.00	1.1
Glu (mg/dL)	123	148	268	101
Lac (mmol/L)	0.9	0.7	5.3	0.5
Hb (g/dL)	10.8	11.5	13.5	13
SO_2 (%)	69.2	94.2	100	98
BE (mmol/L)	−13.6	−1.1	−3.2	+1
HCO_3^- (mmol/L)	13.7	23.0	21.8	24.8
Hct (%)	32	35	41	40

Note: pCO_2: Partial pressure of carbon dioxide; PO_2: Partial pressure of oxygen; Glu: Glucose; Lac: Lactate; Hb: Hemoglobin; BE: Base excess; Hct: Hematocrit.

2. Discussion and conclusions

TCER is a widely performed, minimally invasive procedure with a low complication rate and fast recovery after surgery, being, therefore, the gold standard for myomectomies and metroplasty [1,2]. TCER consists of distending the uterine cavity with an irrigation fluid to obtain a full view of the operating field, allowing surgery via electrical diathermy. Furthermore, a pressurized intrauterine solution provides hemostasis. Uterus irrigation is provided by a peristaltic pump which enables the setting of inflow rate and cavity pressure. The outflow of the distending media is granted either by passive leakage or by an aspirating limb.

Traditionally, electrolyte-poor solutions (i.e., glycine, sorbitol and mannitol) are used as a distending solution to prevent electrical interference with the monopolar resectoscope; these fluids carry a risk of dilutional hyponatremia. The irrigation fluids of choice since the introduction of bipolar resectoscopes are electrolyte-containing crystalloids (such as 0.9% saline [3–7]). Although the use of these fluids decreases the risk of hyponatremia, their absorption can lead to volume overload.

Fluid overload due to massive irrigation fluid absorption is one of the most important complications of hysteroscopic surgery [2]. Absorption of the distending solution leads to fluid overload in 0.06–0.2% of TCERs [8]. Fluid is absorbed intravascularly when its pressure is higher than venous pressure (around 15 mmHg). However, since TCERs occur within hollow organs, the pressure threshold for fluid absorption is best measured as the pressure within the operative site (uterus). Intrauterine pressure values to minimize irrigating solution absorption should be kept below 70 mmHg [9].

Uterine sinuses become exposed and/or severed during surgical maneuvers. Absorption of fluid may occur through these sinuses at a high rate [10] leading to extracellular fluid overload. This process is called intravasation.

During hysteroscopy, fluid can also extravasate through breaches in the uterine wall or through the fallopian tubes into the peritoneal cavity; however, tubal ligation is not proven to affect the volume of fluid absorbed [11].

Large sizes and numbers of removed lesions, depth of myometrial resection, visceral perforation and longer durations of the procedures are risk factors for excess fluid absorption [12].

The presenting signs and symptoms in our case were representative of severe fluid overload and massive 0.9% saline infusion.

Diffuse subcutaneous edema developed due to extravasation in the context of hypervolemia. Signs of impending heart failure were present in the form of hypotension, lung crackles, Kerley B lines and desaturation. Indeed, the hemodynamic response to excessive fluid absorption during transurethral prostatectomy syndrome, which has the same pathophysiology as fluid excess during TCER, has been described as biphasic: A first phase of hypervolemia characterized by pulmonary edema [13] and an increase in central venous pressure, which plateaus within 15 min [14]; and a second phase characterized by low cardiac output, hypovolemia and hypotension [15]. Electrocardiographic signs of myocardial strain such as ST segment depression, bradycardia and flattening of T waves are often observed.

In our case, the myocardial stress and the severe hypokalemia (2.2 mmol/L) caused a clear severe ST segment depression.

Hyperchloremic metabolic and respiratory acidosis was evident from the arterial air blood gas analysis, with a pH of 7.05, a chloremia of 120 mmol/L (normal range 98–106 mmol/L) and a $PaCO_2$ of 61 mmHg as shown in Table 1. In our case, as in most hysteroscopies nowadays, 0.9% saline was employed. Infusion of large volumes of 0.9% saline cause hyperchloremic acidosis because of the supra-physiological content of chloride [16]. Due to the slight hypertonicity compared to plasma, 0.9% saline overload usually does not cause cerebral edema, but acute volume overload is more likely with 0.9% saline compared to other irrigating solutions because of the greater osmolarity that leads to increased plasma volume expansion. The observed hypotension and desaturation were probably due to the synergistic effect of the sudden increase in preload beyond the heart's compensatory ability and myocardial depression due to hyperchloremic acidosis.

Analyzing the acid-base status of our patient using the Stewart approach, the strong ion difference (SID) can be calculated as SID = [strong cations] – [strong anions] = $[Na^+ + K^+] - [Cl^-]$, with a normal value around 40. In this case SID = [140 mEq/L + 2.6 mEq/L] – [120 mEq/L]. The calculated SID was 22, a result that further confirms the traditional approach, being half of the reference value.

The hypercarbia of 61 mmHg was most probably due to the patient's ventilatory drive being reduced in spontaneous breathing under propofol sedation and pulmonary edema.

The etiology of the acidosis was mixed respiratory and metabolic.

After a multidisciplinary examination of the reported case, the chain of events appeared to be caused initially by difficult hemostasis, which led the surgeon to increase the pumping pressure to reduce the profuse bleeding and improve visualization. A profuse hemorrhage means exposure of venous plexuses, which, with increased pressure, could lead to intravasation. The picture was further complicated by leakage of the aspirating limb, preventing the designated personnel to calculate the absorbed volume by the difference between in and out volumes.

Thus, the question arose: What to do to reduce the risk?

As in every medical procedure, the absolute extinction of risk is unachievable. However, it is imperative to act on multiple factors to render the procedure as safe as possible.

First, avoiding non-electrolyte distending solutions virtually eliminates the risk of dilutional hyponatremia [10]. Second, a further safety measure could be the use of Ringer solution instead of 0.9% saline as distending media to reduce the risk of hyperchloremic acidosis.

The aforementioned precautions do not reduce the danger of fluid overload, which is mainly linked to the following factors: (I) Total volume infused, (II) flow, (III) operative time, (IV) intrauterine pressure and (V) in-out volume difference.

The total volume employed during the procedure is related to the flow (volume/min), which is one of the machine settings and the duration of the procedure. There is no fixed extent limit; however, according to several expert opinions, it is good practice to maintain the operative time under the hour [17–19].

The intrauterine pressure should be kept below the level of 70 mmHg, following the principle of maintaining the lowest possible pressure [9]. As explained by the pathophysiology, when the solution has greater pressure than the exposed venous sinuses, intravasation is expected.

A situation of concern is difficult hemostasis: Instinctively, the surgeon may tend to increase flow in an attempt to improve visualization. However, above a certain threshold, the flow will become turbulent, paradoxically worsening the screen image during hemostasis and, in parallel, increasing intravasation.

Overall, the most important value that reflects the absorption of a distending solution is the difference between infused and the aspirated volume. It is a number that must be constantly monitored. In our case, there was a leakage in the aspirating limb. Therefore, the delta in-out could not be estimated with the necessary precision.

It is mandatory, make this procedure safer, for technology to support automatic calculation of the absorbed fluid.

According to the American College of Obstetricians and Gynecologists (ACOG) committee, the procedure should be stopped when the absorption reaches 2500 mL of isotonic solution. This volume must be kept as a general maximal value; however, the heterogeneity between patients is elevated.

Flow, pressure and absorbed fluid should be regulated by a system of audible and visible alarms, activated at predetermined values. Our suggestion is to maintain a constant dialogue among the staff during the case. The surgeon should notify the anesthesiologist if, due to difficult hemostasis and visualization, increased operative time and pressure are necessary.

A special concern involving the Storz Hamou® Endomat® is that the display does not show any value of pumped-in or aspirated volume. The gynecologist and the operating room team must keep track of the volumes of saline solution left in the saline bags and the volume in the aspiration bag. No digital or analogical alarm reports a significant discrepancy between in-flow and out-flow. Additionally, the same machine also supports the tubing system employed for laparoscopy. The peristaltic pump automatically recognizes the increased diameter and sets considerably higher values of flow and pressure, leading to an enormous risk of volume overload.

In a surgical room where both hysteroscopy and laparoscopy are realized and where both tubing systems are available, exchange between tubing systems is possible. Adequate color coding, human expertise and procedure-specific devices could prevent the disastrous consequences of this error.

A maximal threshold of pressure, flow, operative time and absorbed volume should be pre-determined to anticipate the possible risk, knowing unanimously when to interrupt the procedure, predisposing further diagnostics and treatments. Termination of the procedure, hemodynamic and respiratory support, electrolyte management and diuretic administration are the mainstay of treatment.

Intrauterine vasopressin and terlipressin are being investigated to reduce fluid intravasation and improve hemostasis through vasoconstriction [20].

In conclusion, all members of the surgical room staff must be acquainted with the prevention methods, risk factors, instrumentation flaws, recognition of possible red flags and management of intravasation-induced fluid overload. Regular simulated scenarios with appropriate debriefing, similar to aviation crews, are interesting tools to make these procedures as safe as possible. Simulation has proven to increase both technical and non-technical skills in the medical setting, improving patients' outcomes. Other than sharpening clinical knowledge, high-fidelity settings enforce teamwork in a professionally heterogeneous environment.

Use of AI tools declaration

The authors declare that they have not used Artificial Intelligence (AI) tools in the creation of this article.

Conflict of interest

All authors declare no conflicts of interest in this paper.

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