REVIEW ARTICLE

COLONOSCOPY PREPARATIONS: ELECTROLYTE IMBALANCES AND PRECAUTIONS IN THE FRAGILE PATIENTS.

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Abstract

Bowel preparation intake for colonoscopy can cause electrolyte imbalances. Although it is a rare complication, occurs as a consequence of the loss of electrolytes and water into the intestinal lumen, and because some electrolytes from the preparations can be absorbed. The possible imbalances cover all the alterations range of the internal environment (hypo and hypernatremia, hypo and hyperkalemia, metabolic acidosis, hypocalcaemia, and hyperphosphataemia or hypermagnesaemia). Electrolyte disturbances and their severity depend on electrolyte content of the preparation solution, the fluid replenishment conducted, and patient characteristics.

Electrolyte imbalances are generally transient, and these should not cause complications if adequate fluid replenishment with or without electrolytes during bowel preparation is conducted and maintained over time once the colonoscopy is performed. We reviewed the most frequent electrolyte imbalances that occur with the most used bowel cleansing preparations and precautions to be taken into consideration in fragile patients.

Keywords: colonoscopy, bowel preparations, hyponatremia, hypernatremia, hypermagnesaemia.

Introduction

Colonoscopy is one of the most frequently used medical procedures. It is considered the Gold-standard technique for colorectal cancer (CRC) screening, as well as for the removal of adenomatous polyps with precancerous potential[1,2]. Colonoscopy is estimated to reduce CRC incidence by 40% and mortality by 60%[3].

The diagnostic effectiveness of this technique depends on good bowel cleansing, so the use of bowel preparations is essential. Inadequate cleansing has a detrimental effect on all aspects of the colonoscopy procedure, leading to significantly lower rates of adenoma detection[4], failure of cecal intubation, increased operative time and associated complications, and the need for repeat procedures. In summary, higher healthcare costs[2,5].

The ideal preparation should achieve excellent cleanliness allowing visualisation of the entire colonic mucosa without the need to remove residues during the examination. It should also be safe for the patients, with good tolerability and easy compliance[6].

The most commonly used preparations for colonoscopy are 4-litre polyethylene glycol (PEG), PEG + 2-litre ascorbic

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acid, PEG + 1-litre ascorbic acid and sodium picosulphate + magnesium sulphate (PCM)[5]. This availability of different bowel cleansing preparations, both in composition and volume, makes it possible to choose the most appropriate one for each patient according to their specific characteristics and comorbidities[5]. Thus, iso-osmotic bowel preparations contain an iso-osmotic liquid and a non-absorbable polymer (PEG) that causes the ingested liquid to be retained in the lumen of the colon. These preparations are considered safer for patients at risk of water and electrolyte disturbances, as they do not cause significant electrolyte or water changes. On the other hand, hyperosmotic bowel preparations provide a large amount of osmotically active molecules with a smaller volume of fluids. The ingested osmoles draw fluid into the colon and stimulate evacuation. However, this fluid exchange process can result in intravascular volume contraction and electrolyte disturbances[2,5].

The main colonoscopy preparations have been shown to provide adequate bowel cleansing safely in healthy individuals without significant comorbidity[6]. However, occasionally disturbances are described as a consequence of water and electrolyte loss through the intestinal lumen, or absorption of some of the electrolytes contained in the preparations. Thus, the possibilities cover almost the entire spectrum of alterations of the internal environment (hypo- and hypernatraemia, hypo- and hyperkalaemia, metabolic acidosis, hypocalcaemia and hyperphosphataemia or hypermagnesaemia)[7,8].

The possibility of suffering these alterations and their severity will depend on the electrolyte content of the preparation, the type of replenishment performed and the characteristics of the patient. Generally, these are transitory alterations that, with adequate fluid replacement with or without electrolytes during the bowel preparation, and maintained over time once the colonoscopy has been performed, should not cause problems[7].

The risk is particularly high in certain population groups. This is the case, for example, in the elderly, who have an altered thirst mechanism and in whom it is necessary to insist on fluid intake to obtain adequate replacement. Also in patients with nephropathies or under diuretic treatment whose ability to concentrate urine is impaired. Patients with heart failure or cirrhosis of the liver, who not only have electrolyte disturbances and volume overload, but are also more vulnerable to changes in ion concentrations, with a higher incidence of arrhythmias. Finally, mention should be made of patients being treated with insulin or with drugs that may affect water-electrolyte balance (NSAIDs, ACE/ARB II, diuretics, corticosteroids) or make them more vulnerable to these imbalances (cardiac glycosides, carbamazepine, etc.)[7,8].

This article reviews the most frequent hydroelectrolyte alterations (hyponatraemia, hypernatraemia and hypermagnesaemia) that may occur with the most commonly used intestinal cleansing preparations in Spain (PEG and PCM-based solutions[5]) and the precautions to be considered in fragile patients.

Alterations in plasma sodium concentration

Both hyponatraemia and hypernatraemia are disorders that reflect alterations in plasma sodium concentration ([Na]), i.e. disorders in the regulation of water and not of a greater or lesser total amount of sodium. The fundamental premise for the correct management of these disorders is to remember that [Na] is a reflection of the osmolality of the extracellular fluid. Changes in osmolality imply changes in the amount of water, whereas a change in the total amount of sodium determines the total amount of extracellular fluid and implies changes in volume[9].

Hyponathremia

Hyponatraemia ([Na] <135mmol/l) is a relatively common condition in hospitalised patients, with an incidence and prevalence in adults of 1 and 2.5%, respectively. Its occurrence implies that there is a gain of free water, either due to excessive water intake (oral or parenteral) or due to renal difficulty in excreting it[10].

Symptoms (apathy/agitation, fatigue, anorexia, nausea, headache, muscle cramps, tachycardia, oliguria/anuria and confusion) appear with [Na] <120-125 mmol/L. If [Na] values <110/115 mmol/L are reached, the patient may experience convulsions, coma and shock[9].

Intake of large volumes of water, especially in patients with reduced free water clearance, predisposes to the development of hyponatraemia[6]. In the colonoscopy setting, after taking the bowel cleansing preparation, this imbalance may occur as a consequence of intravascular volume depletion (mainly due to diarrhoea) and subsequent excessive thirst, or due to abundant water intake in a short time together with the bowel preparation agent and low solute intake. It may also occur as a consequence of difficulty in eliminating free water and increased antidiuretic hormone release, which during bowel preparation may be triggered by nausea, pain or anxiety[7].

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PCM based preparation has been associated with hyponatraemia in patients with no risk factors for sodium concentration abnormalities[7]. Severe cases of hyponatraemia have even been reported with PCM as a consequence of intravascular volume depletion (Table 1)[11-23]. A retrospective study found a higher risk of hospital admission for hyponatraemia in patients >65 years prepared with PCM than with PEG preparations[5,12].

In the case of PEG-based solutions, the occurrence of hyponatraemia has been associated with the syndrome of inappropriate antidiuretic hormone secretion. Several cases of hyponatraemia have also been reported with the 4L PEG preparation following excessive water intake in a short period of time[6,24-27].

Hyponatraemia may have more severe consequences when it develops rapidly (<48 hours), or in patients with individual susceptibility or underlying neurological disease. It is therefore advisable to counsel patients and instruct them that replacement fluids should be isotonic solutions, avoiding drinking only water or hypotonic beverages which may lead to electrolyte imbalance.

Hypernatremia

Hypernatraemia ([Na] >145 mmol/L) is less common than hyponatraemia and usually occurs as a result of water loss or, more rarely, sodium gain(10). When a small rise in sodium occurs, the body stimulates the thirst centre and the release of antidiuretic hormone (ADH). Thirst is paramount as even maximal ADH secretion may fail to retain enough water to compensate for losses. Thus, thirst provides the ultimate protection against hypernatraemia and it is very difficult for hypernatraemia to exceed 150 mmol/L [Na] in adults without consciousness deficits, with normal thirst mechanism and/or free access to water[9,28]. When hypernatraemia due to water loss occurs, it is usually in patients with hypodipsia or, more commonly, in adults with altered mental status or without access to water[10].

Symptoms that may occur include weakness, somnolence, confusion and convulsions. The manifestation of these symptoms depends on how quickly hypernatraemia has developed, but they are unlikely at [Na] below 155 mmol/L[28]. Symptoms of central nervous system dehydration (thirst, dry skin and mucous membranes, weight loss, confusion, hallucinations and coma) appear at [Na] >160 mmol/L[28].

Isoosmotic preparations themselves do not affect [Na], but in patients with impaired renal water management or in elderly patients with decreased thirst there is a risk of hypernatraemia. For example, severe hypernatraemia with acute kidney injury (in the range of 166 mEq/L) has been reported with oral sodium phosphate (SP) preparations in elderly patients with poor water intake[29-30]. In fact, the ESGE (European Society of Gastrointestinal Endoscopy) guideline does not recommend the use of FS for routine bowel preparation[5].

PEG-based preparations contain added electrolytes to create iso-osmotic solutions. They are absorbed to a minimal extent in the intestine, even if the mucosa is not intact (e.g. in patients with inflammatory bowel disease)[5]. They are also considered safe in patients at risk of water-electrolyte disorders, as they do not cause significant electrolyte or water exchange across the colon wall[5].

With high-volume (4L) PEG solutions, studies have shown no significant alterations in vital or electrolyte parameters[5].

In the case of very low volume (1L) PEG preparations, the electrolytes present in the formulation, together with additional intake of clear fluids, prevent clinically significant changes in sodium, potassium or water levels. However, mild and transient hypernatraemia of no clinical significance has been reported in both trials and clinical practice[31-34]. A study evaluating renal function in patients hospitalised after bowel preparation with PEG 1L or PEG 4L did not observe significant electrolyte alterations, neither in renal function nor in hydration as assessed by haematocrit[35]. Finally, no clinical events attributable to electrolyte imbalance or dehydration were observed in patients >65 years of age[36-37].

Among the recommendations, good hydration should always be ensured in accordance with the losses and the patient's pathology. It is important to note that the replenishment process does not end at the time of colonoscopy, but should be maintained until the following day. In patients prepared with very low volume PEG (1L), this replenishment should be done with free water, avoiding isotonic drinks. Finally, in patients at risk, as well as in those with vomiting during the preparation and/or who have not followed adequate hydration guidelines, special monitoring of electrolyte levels should be carried out before and after treatment.

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Reference	Gender	Age (years)	Symptoms	Sodium levels (mmol/L)	Preparation
(14)	Female	76	Loss of consciousness and seizures	112	SPMS
(15)	Female	64	Seizures	111	SPMS
(15)	Female	75	Seizures	116	Phosphosode + Bisacodyl
(15)	Female	27	Seizures	132	Phosphosode + Bisacodyl
(16)	Female	65	Nausea and vomiting	124	SPMS
(16)	Female	74	Acute confusion	120	SPMS
(16)	Female	73	Seizures tonic-clonic	115	SPMS
(17)	Female	80	Acute confusion and generalized seizures	110	SPMS
(18)	Female	57	Seizures tonic-clonic	120	SPMS + Bisacodyl
(19)	Female	78	Disorientation and dizziness	108	SPMS
(20)	Female	64	Coma	111	SPMS
(20)	Female	69	Dysarthria and paresthesia in upper limbs	128	SPMS
(21)	Male	48	Coma	110	SPMS
(22)	Female	61	Encephalopathy	122	SPMS
(23)	Female	62	Convulsiones	119	SPMS
(24)	Female	59	Seizures	120	PEG 4L
(25)	Female	73	Seizures tonic-clonic	117	Gatorade 2L mixed with 225 g of PEG3350 (Miralax)
(26)	Female	64	Weakness in lower limbs	118	PEG 4L
(27)	Female	70	Seizures tonic-clonic	110	PEG 4L +3L Water
(27)	Female	65	Seizures tonic-clonic	127	PEG 4L

PEG: polyethylene glycol; SPMS: sodium picosulfate + magnesium sulfate.

Figure 1. ***Characteristics and presentation of patients with symptomatic hyponatraemia related to bowel preparations reported in the literature.***

Hypermagnesaemia

Various preparations containing PCM may cause a transient increase in serum magnesium levels[6].

Due to their hyperosmolarity and magnesium content, these solutions are contraindicated in some patients. For example, those with congestive heart failure, hypermagnesaemia, rhabdomyolysis, gastrointestinal ulcers or in patients with severely impaired renal function who may suffer from magnesium toxicity (as the kidney is primarily responsible for magnesium elimination)[5,7].

Magnesium-free preparations do not confer an increased risk of hypermagnesaemia[7].

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Conclusions

After preparation with hyperosmotic solutions, fluid replacement should always be done with electrolyte solutions, avoiding free water or hypotonic drinks.

After preparation with iso-osmotic solutions, fluid replacement should be done with free water or hypotonic beverages.

In patients in whom any preparation regimen carries a risk of dehydration and/or possible electrolyte imbalances (even caused by vomiting alone), hyperosmotic preparations may further increase these risks[5].

PCM-based preparations should be used with caution in patients at risk (congestive heart failure, liver cirrhosis or hepatic failure with ascites, chronic kidney disease, etc.) or suffering from hypovolaemia (such as patients taking high doses of diuretics)[2,5-8].

Isoosmotic solutions are safer options in patients with relevant comorbidities or treated with medications that influence water and electrolyte balance[2,5-8].

In elderly patients, osmotically balanced PEG-based solutions are the preparations of choice as they are considered the safest[2,5-8].

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