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Relation between hyponatraemia and falls by acute hospitalised patients: A case-control study

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Abstract

Aims and objectives: To investigate the possible association between hyponatremia and falls, in a sample of hospitalised adult patients.

Background: In-hospital falls are a problem of major importance, provoking a significant decline in the quality of life of many patients. Recent studies have identified a relationship between such falls and the presence of hyponatremia.

Design: Analytical retrospective observational case-control study.

Methods: The study population consisted of hospitalised patients who had suffered an in-hospital fall during the period 2014–2016. For each case, two controls who had not suffered any such fall were recruited. These cases and controls were matched according to gender, age, hospitalisation unit and date of admission. Study data were obtained from the hospital's record of falls, regarding the patients' socio-demographic factors, physical and psychological conditions and blood levels of sodium, potassium, urea and creatinine. The study is reported in accordance with STrengthening the Reporting of OBservational studies in Epidemiology guidelines.

Results: The study sample consisted of 555 patients (185 cases and 370 controls). Hyponatraemia was detected in 57 cases (30.8%). A statistically significant relationship was found between the presence of hyponatraemia and the occurrence of falls: OR = 2.04. Other risk factors for falls were hypercreatinaemia OR 2.49, hyperuraemia OR 1.82, disorientation, need for ambulatory assistance and longer hospital stay.

Conclusions: From the study findings, we conclude that hyponatraemia is a predictor of falls by acute hospitalised patients. Further research is needed on the relationship between hypercreatinaemia, hyperuraemia and falls.

Relevance to clinical practice: The assessment of risk factors for falls, such as hyponatraemia, can alert us to the possibility of this event occurring and facilitate the implementation of preventive measures. This parameter should be included as a significant new factor in assessment instruments designed to assess the risk of falls, thus enhancing the reliability and diagnostic validity of these instruments.

KEYWORDS
accidental falls, hospitalised patients, hyponatraemia, nursing, risk factors

1 | INTRODUCTION

The World Health Organization (WHO) defines falls as involuntary events that cause the body to lose its balance and find itself on land or on another firm surface that stops it (WHO, 2018). A major public health problem is caused worldwide by the estimated 37.3 million falls suffered each year, of which 646,000 are fatal (WHO, 2018). The resulting injuries reduce mobility and independence and increase the risk of premature death. It has been estimated that in hospitals 12% of fallers suffer adverse events, with injuries being the most frequent and, to a lesser extent, fractures or brain hemorrhages (Kobayashi et al., 2017). Moreover, falls are the predominant cause of injuries among persons aged over 65 years. According to the WHO (2018), the highest mortality rates due to falls are among persons aged over 60 years. Research has shown that 27% of those aged over 65 years will fall at least once a year and that 15% of elderly persons will fall more than once a year (Ganz et al., 2007). In addition to the physical outcome, there are also psychological consequences (termed the post-fall syndrome), which can affect up to 50% of persons who have suffered a fall. The fear of suffering another fall often provokes a loss of confidence in the ability to perform everyday activities, thus reducing mobility and functional capacity (Cruz et al., 2014). Falls were the second most reported adverse event in hospitals in 2018 (The Joint Commission, 2019), while the prevalence of falls by patients in Spanish hospitals has been estimated at 6.3% (Durán et al., 2017).

Falls are an indicator of the quality of care in hospitals (Parra Hidalgo et al., 2012). In consequence, administrations have highlighted the need to prevent such falls as an important element of health care policies (Ministerio de Sanidad & Servicios Sociales e Igualdad, 2016). In a Spanish hospital the incidence of falls is reported to be 0.64% (n = 19,893) (Aranda-Gallardo et al., 2014).

What does this paper contribute to the wider global clinical community?

- The study enhances our understanding of the problem of in-hospital falls.
- The results obtained will facilitate the implementation of fall prevention measures for patients with hyponatraemia.
- The findings reported could be used to improve the reliability and validity of instruments used for assessing the risk of falls by hospitalised patients.

2 | BACKGROUND

The causes of falls are multifactorial and may be intrinsic or extrinsic. Intrinsic factors include age and physiological changes. Thus, advanced age (over 65 years) is strongly associated with in-hospital falls (odds ratio [OR] = 2.1. 95% CI 1.7–2.7; Härlein et al., 2011). Other intrinsic causes of falls include acute or chronic illness, altered consciousness, difficulty in walking, impaired balance, a history of previous falls, and polypharmacy. Extrinsic causes include poor lighting, the presence of steps or slippery floors, and other environmental factors (Ambrose et al., 2015; Deandrea et al., 2013).

The importance of this clinical safety issue has motivated the design and implementation of various measurement scales and instruments to identify the risk of falls and facilitate preventive action. However, the practical value of these instruments has been questioned, due to their poor diagnostic validity in the health care context (Aranda-Gallardo et al., 2017) and they are not currently recommended to detect the risk of in-hospital falls (National Institute for Health & Care Excellence, 2013).

In response to this perceived shortcoming, other parameters are being investigated to develop instruments that are sensitive, specific and capable of providing a more objective estimate of the risk of falls. One such parameter is hyponatraemia (low blood sodium), which has been associated with an increased risk of falls. In this respect, studies have reported OR of 2.18 (Tachi et al., 2015) and 3.12 (Ahamed et al., 2014). This condition may also be related to an increased duration of hospital stay (OR 1.48) and to a higher degree of care dependence (Ahamed et al., 2014).

Hyponatraemia has been recorded in 15%–20% of patients admitted to hospital A&E departments and may be associated with a greater severity of falls (Ayus et al., 2017). It has an incidence of 3% among outpatients, but up to 20% among patients hospitalised in General Medicine departments (Upadhyay & Gormley, 2012) and 15%–30% in intensive care units (Sahay & Sahay, 2014), which highlights the potential impact of this condition on the possible occurrence and consequences of in-hospital falls.

The causes of hyponatraemia vary widely, but include excessive fluid intake, kidney failure, heart failure, cirrhosis and the consumption of diuretics. These processes can also provoke other alterations such as hyperuraemia, hypercreatinaemia or hyperkalaemia (Castellanos et al., 2016).

The presence of hyponatraemia in patients who suffer falls has been associated with a greater severity of their consequences. Thus, among these patients, a 1.4-fold increase in the incidence of non-vertebral fractures and a 1.8-fold increase in that of hip fractures have been reported (Hoorn et al., 2011). Moreover, patients with chronic hyponatraemia are at greater risk of suffering fractures (OR 4.61, 95% CI 4.15–5.11). Among patients who suffer a fall within 30 days of the measurement of plasma sodium, an OR of 3.05 has been reported (95% CI 2.83–3.29), and among those with recently diagnosed chronic hyponatremia, the OR for fractures is 11.21 (95% CI 8.81–14.26; Usala et al., 2015).

However, there is some controversy as to the most appropriate cut-off value for the detection of hyponatraemia. Some authors use a threshold of 135 mEq/L, below which the risk of falls is aggravated: OR 3.71 (95% CI 1.6–8.3; Lobo-Rodríguez et al., 2016). Others prefer a lower threshold (125 mEq/L) and have detected an even stronger association: OR 5.08 (95% CI: 1.43–18.08; Fehlberg et al., 2017).

Various studies have indicated the relevance of hyponatraemia to the occurrence of falls and the severity of its consequences, and all agree that further research is needed to corroborate and extend the results obtained thus far. Some researchers have focused exclusively on patients aged over 65 years (Ahamed et al., 2014; Lobo-Rodríguez et al., 2016); others have used scales reflecting the risk of falls in their selection of study participants (Lobo-Rodríguez et al., 2016), a strategy that in fact is of no predictive value for hospitalised patients (Aranda-Gallardo et al., 2017). Finally, Fehlberg et al. (2017) highlighted the need to explore other analytical values that may be related to hyponatraemia. Taking into account the above research, its achievements and limitations, the present study was undertaken to address the perceived knowledge gap regarding hyponatraemia and the risk of in-hospital falls, including an analysis of other analytical parameters related to the metabolism and plasma levels of sodium, such as urea, creatinine and potassium.

The aim of this study is to evaluate the association between hyponatraemia and falls by hospitalised acute patients. Specifically, we examine the frequency, characteristics and consequences of the falls experienced by hospitalsed patients during the study period, and consider whether alterations to the levels of serum potassium, creatinine and urea bear any relationship to the fall events.

3 | METHODS

3.1 | Design

Analytical retrospective observational case-control study.

3.2 | Data collection

The study population was composed of adult patients hospitalised at a Spanish hospital during the period 1 January 2014 to 31 December 2016. The study cases were identified from the records of in-hospital falls. For each case included in the study, two controls were also recruited, matched by hospital unit, date of stay (within a week of the admission of the patient who had suffered the fall), gender and age.

The following inclusion criteria were applied: patients aged over 14 years, hospitalised in any medical or surgical unit during the study period and blood analysis performed before and after the fall (in cases), including the study parameters, or at least one analysis performed during the hospitalisation including the study parameters (in the controls). The exclusion criteria were absence of hospitalisation, patients who had suffered a fall in the A&E area or during outpatient visits, dialysis, functional tests or medical or surgical day hospital visits. Moreover, obstetric and paediatric patients were excluded from consideration. To avoid possible confounding effects associated with hyponatraemia, patients with prior kidney disease (kidney failure, pyelonephritis, obstructive lithiasis, glomerulonephritis or renal amyloidosis) or who had had a kidney transplant were also excluded.

The hospital maintains a computerised record of in-hospital falls by patients, the data for which are provided by the clinical nurses concerned. This list was consulted for the present study, in which falls are defined in accordance with the WHO (2018), as follows: "… involuntary events that cause the body to lose its balance and find itself on land or on another firm surface that stops it" (WHO, 2018). To select the accompanying controls, we first consulted the list of admissions to hospitalisation units during the study period and then matched cases and controls by gender, age, date of admission and hospital unit.

The analytical values required for the study were those obtained immediately before and after the fall, according to the corresponding clinical history (cases), or from baseline data for the patient on initial hospitalisation (controls). Other characterisation data obtained for each patient were age, gender, clinical history number, admission unit, admission date, discharge date, duration of stay (days), room number, cognitive status (conscious and well oriented, disoriented, agitated, unconscious, confused or comatose), mobility at the time of admission (independently ambulatory, ambulatory with assistance, in bed/chair during the stay, or bedridden), history of falls, visual or auditory alterations, levels of blood sodium, potassium, creatinine and urea, and date of the analysis (for the cases, the samples for analysis were taken before and after the fall). For the cases, data were also obtained from the hospital's record of falls, including the circumstances in which the fall(s) occurred (when the patient was alone, during ambulation, while visiting the bathroom), the hospital shift during which the fall occurred (morning, afternoon or night) and the consequences observed (none, bruising, wound not requiring stitches, wound requiring stitches, fracture). The reference serum threshold for hyponatraemia was taken as sodium <135 mEq/L; for hypercreatinaemia, creatine >1.3 mg/dl in men and 1.1 mg/dl in women; for hyperuraemia, urea >50 mg/dl; for hyperkalaemia, potassium >5 mEq/L.

3.3 | Data analysis

The descriptive statistics obtained included measures of central tendency, dispersion and frequency. The normality of the distributions

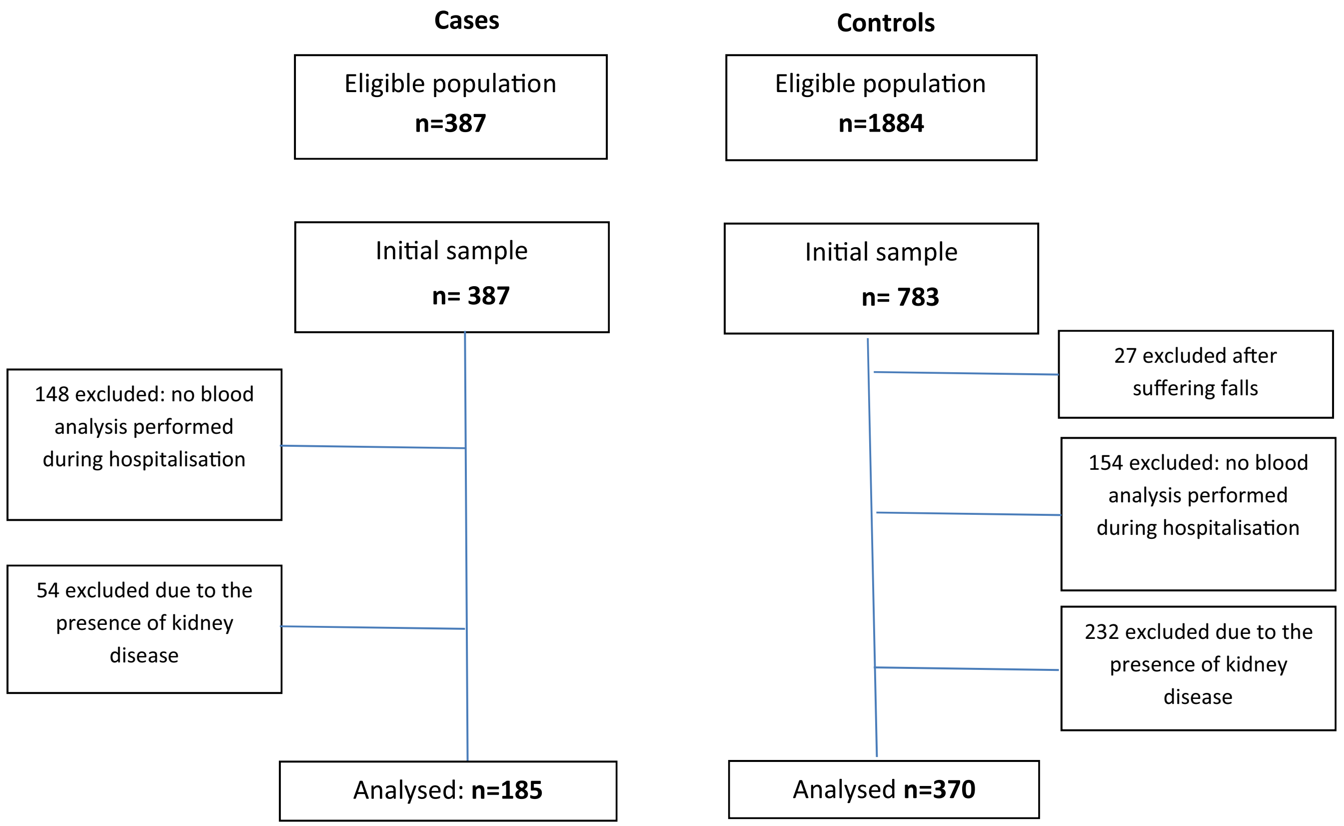

FIGURE 1 Study flow chart

was examined by the Kolmogorov-Smirnov test. Non-normal distributions were subjected to bivariate analysis of the differences of the means, using Student's t for quantitative independent variables (and Mann-Whihney U test in case of non-normal distribution or median difference with Hodges-Lehmann test). Differences in proportions were determined by the chi-square test.

A post-hoc analysis of the study sample was performed to check the statistical power obtained, to ensure it was unaffected by any type II error.

A multivariate logistic regression analysis was performed to evaluate the condition of being a case (faller) for each of the outcome variables (one model for each: hyponatraemia, hypercreatinaemia, hyperkalaemia and hyperuraemia), adjusted by age, gender and type of unit as an entry condition, describing the OR with their respective 95% CI.

The sample data were compiled between December 2017 and April 2018. The results obtained were analysed in May 2018. All these statistical analyses were performed with SPSS 23 statistical software.

To guarantee the quality of the results presented, the standards of the checklist for observational studies (including case-control studies) proposed by the international collaborative initiative STROBE (STrengthening the Reporting of OBservational studies in Epidemiology; Von Elm et al., 2009) were followed (File S1).

3.4 | Ethics

Authorization by the Hospital Research Ethics Committee was obtained before starting the study. The rules of good clinical practice and the ethical principles established for research in human beings in the Declaration of Helsinki and its subsequent revisions were upheld at all times. The patients' clinical characteristics were segregated from their identifying data, and the corresponding databases were protected with access codes and stored on computers used exclusively for this project.

4 | RESULTS

During the study period, 387 patients suffered 406 falls. Of these patients, 185 met all the criteria for inclusion in the study. Hence, the study sample consisted of 185 cases, together with 370 controls (two for each case), matched by date of admission, hospital unit, gender and age. The total sample consisted of 555 patients (Figure 1), of whom 387 (69.7%) were male and 168 (30.3%), female, with a mean age of 71.97 (*SD* 11.42) years, ranging from 37 to 94 years. There were no significant differences between the cases and controls as regards their mean age (72.44 years, *SD* 11.31 vs. 71.73 years, *SD* 11.64, respectively; p = .383). These characteristics are detailed in Table 1. For the cases, the median duration of hospitalisation was 15 days (25th–75th percentiles: 9–24), while that of the controls was 7 days (25th–75th percentiles: 5–11), which represents a statistically significant difference (median difference: 8, 95% CI: 6–9; $p < .001$). With respect to the location of the bed assigned to each patient, for the purposes of our analysis, the rooms were classified according to their proximity to or distance from the nursing control centre, according to the plan of hospitalisation rooms within each hospital unit. Regarding the proximity of the hospital room to the nursing control centre, there were no significant differences between cases and controls. By type of hospitalisation unit, most of the cases (88.6%) suffered falls in a medical unit (44.7% in that of Internal Medicine), and only 11.4% in a surgical unit. The adjusted analysis by type of unit did not reveal significant differences between these locations.

Regarding the level of mobility when admitted to hospital, most of the cases required help for ambulation (91.4%). There was a significant relationship between the need for ambulatory assistance and the subsequent occurrence of one or more falls: OR = 7.62 (95% CI 4.37–13.28).

In relation to the patients' cognitive status (Table 2), most of the cases were well oriented (63.8%). Regarding disorientation, there was a 26.5% difference between cases and controls, OR = 5.92 (95% CI 3.52–9.96). In most of the fall events, the patients were not using a handrail (61.6%), were unaccompanied (76.8%) and had no mechanical restraint (83.2%). The majority of falls (60%) occurred during the night shift. Only 24.3% had clinical consequences, which in most cases took the form of bruising or wounds not requiring stitches (86.7%) (Table 2).

Regarding sodium levels, 22.34% (n = 124) of the total sample had hyponatraemia. Of these, 57 were cases (30.81% of all cases) and 67 were controls (18.11% of all controls). For the whole sample, the mean blood sodium level was 138.47 mEq/L (*SD* 5.24). These values were significantly lower among the cases (136.92 mEq/L; *SD* 5.38) than the controls (139.24 mEq/L; *SD* 4.99). Regarding the relation between the presence of hyponatraemia and the consequences of any fall suffered, 17 of the 45 cases who suffered such a consequence had hyponatraemia, but the relationship was not statistically significant: OR 1.52 (95% CI 0.75–3.07).

The following analytical values were obtained for creatinine, urea and potassium. The mean blood creatinine level in the cases (1.21 mg/dl; *SD* 1.07) was significantly higher than in the controls (0.92 mg/dl; *SD* 0.48; $p < .001$). The same relation was observed for mean blood urea, which was significantly higher among the cases (59.2 mg/dl; *SD* 38.98) than the controls (50.4 mg/dl; *SD* 32.02). However, no statistically significant differences between cases and controls were observed for mean potassium values in the blood (4.18 mEq/L; *SD* 0.71 and 4.22 mEq/L; *SD* 0.59, respectively).

A multivariate analysis was performed for every plasmatic chemical variable (hyponatraemia, hypercreatinaemia, hyperkaliemia and hyperuraemia), using conditional logistic regression and including for the adjustment the variables type of hospital unit, gender and age. This analysis confirmed the existence of an association between hyponatraemia and falls, with an OR of 2.04 (95% CI: 1.35–3.09; Table 3). In relation to hypercreatinaemia, the threshold blood creatinine values considered were 1.3 mg/dl for men and 1.1 mg/dl for women. The adjusted model showed that the presence of hypercreatinaemia (OR = 2.49; 95% CI 1.61–3.85) or hyperuraemia (OR = 1.82; 95% CI 1.24–2.68) in these patients was statistically associated with their suffering one or more falls. However, this was not so for those with hyperkalaemia (OR = 1.32; 95% CI 0.72–2.39; Table 3).

5 | DISCUSSION

The main aim of this study was to determine whether there is an association between hyponatraemia and the occurrence of in-hospital falls. The results obtained from our multivariate analysis confirm that hyponatraemia is an independent predictor of falls. The conditional logistic regression model is applied when a strata design is used, with a series of potentially disturbing variables (type of hospital unit, gender and age in our study) and it is intended to estimate the association between the outcome variable and exposure in each stratum. This procedure allows you to control for potential confounders. For this reason, the results obtained confirm that hyponatremia is shown to be an independent risk factor for falls in hospitalized patients. Moreover, the logistic regression permits to compare the strength of the association among the different plasmatic chemical values by means of the OR obtained by each one of them.

Lobo-Rodriguez et al. (2016), in a study with a similar design, albeit with a smaller sample (206 hospital patients), obtained comparable results, with an adjusted OR of 3.71 (95% CI 1.64–8.38).

Fehlberg et al. (2017) reported an OR of up 5.08 (95% CI 1.43–18.08) in their analysis of the hyponatraemia-falls relation, but used a much lower threshold for blood sodium levels (125 mEq/L). When these authors took reference values below 135 mEq/L, as in the present study, the resulting OR adjusted for parameters similar to those addressed in our study was closer to our results: OR = 1.36 (95% CI 1.01–1.82).

In the present study, no relation was detected between falls by patients with hyponatraemia and the consequences of these falls. In contrast, some prior studies have reported an association between this condition and more serious consequences. Thus, Usala et al. observed that chronic hyponatraemia was related to a higher incidence of fractures as a consequence of falls (OR 4.61 95% CI 4.15–5.11; Usala et al., 2015). This finding was confirmed by a systematic review and subsequent meta-analysis, according to which patients with hyponatraemia were at higher risk not only of falls (OR = 2.44 95% CI 1.97–3.02), but also of fractures, especially to the hip: OR = 2.00 (95% CI 1.43–2.81; Corona et al., 2018).

Our study results show that hypercreatinaemia and hyperuraemia may also be predictors of falls. In this respect, Fehlberg et al. (2017) reported that high levels of blood urea nitrogen and of serum creatinine were significantly associated with lower odds of experiencing an in-hospital fall (OR = 0.64; $p = .001$ and OR = 0.70; $p = .009$, respectively), and thus acted as protective factors. However, the reference values used for hypercreatinaemia in men (>1.2 mg/dl) differ

TABLE 1 Characteristics of the sample

Variables	Cases (*n* = 185)	Controls (*n* = 370)	Total sample (*n* = 555)	*p*
Mean age (*SD*)—years	72.44 (11.64)	71.73 (11.31)	71.97 (11.42)	.383
Median hospital stay (25th–75th percentile)	15 (9–24)	7 (5–11)	9 (6–15)	<.001
Gender: *n* (%)				
Male	129 (69.7)	258 (69.7)	387 (69.7)	.990
Female	56 (30.3)	112 (30.3)	168 (30.3)	
Type of unit: *n* (%)				
Medical	164 (88.6)	328 (88.6)	492 (88.6)	.990
Surgical	21 (11.4)	42 (11.4)	63 (11.4)	
Room location: *n* (%)				
Near the nurses' desk	97 (52.4)	193 (52.2)	290 (52.3)	.952
Distal from the nurses' desk	88 (47.6)	177 (47.8)	265 (47.7)	
Mobility: *n* (%)				
Ambulatory unassisted	16 (8.6)	145 (39.2)	161 (29.0)	<.001
Ambulatory with assistance	169 (91.4)	45 (12.2)	214 (38.6)	
Habitual bed/chair	0 (0)	56 (15.1)	56 (10.1)	
Bedridden	0 (0)	100 (27.0)	100 (18.0)	
Not stated	0 (0)	24 (6.5%)	24 (4.3)	
Cognitive status: *n* (%)				
Orientated	118 (63.8)	275 (74.3)	393 (70.8)	<.001
Disorientated	61 (33)	24 (6.5)	85 (15.3)	
Agitated	6 (3.2)	2 (0.5)	8 (1.4)	
Unconscious	0 (0)	2 (0.5)	2 (0.4)	
Confused	0 (0)	16 (4.3)	16 (2.9)	
Stupefied	0 (0)	12 (3.2)	12 (2.2)	
Comatose	0 (0)	6 (1.6)	6 (1.1)	
Not stated	0 (0)	33 (8.9)	33 (5.9)	
Sodium: mean value (*SD*)	136.92 (5.38)	139.24 (5)	138.47 (5.24)	<.001
Creatinine: mean value (*SD*)	1.21 (1.07)	0.92 (0.48)	1.02 (0.74)	.001
Potassium: mean value (*SD*)	4.18 (0.71)	4.22 (0.59)	4.21 (0.63)	.267
Urea: mean value (*SD*)	59.2 (38.98)	50.4 (32.02)	53.33 (34.7)	.008
Hyponatremia: *n* (%)				
Yes	57 (30.8)	67 (18.1)	124 (22.3)	.001
No	128 (69.2)	303 (81.9)	431 (77.7)	
Hypercreatinaemia: *n* (%)				
Yes	57 (30.8)	57 (15.4)	114 (20.5)	<.001
No	128 (69.2)	313 (84.6)	441 (79.5)	
Hyperkalaemia: *n* (%)				
Yes	20 (10.9)	31 (8.4)	51 (9.2)	.329
No	163 (89.1)	339 (91.6)	502 (90.8)	
Hyperuraemia: *n* (%)				
Yes	95 (51.4)	139 (37.6)	234 (42.2)	.036
No	90 (48.6)	231 (62.4)	321 (57.8)	

slightly from those in the present study (>1.3 mg/dl). Moreover, these authors did not explore the relationship between hyperuraemia and falls. In consequence, further research is needed into the impact of hypercreatinaemia and hyperuraemia on the incidence of falls, since the existing bibliography in this respect is very limited and the results presented contradict those obtained in the present study.

Our analysis of the circumstances in which the falls occurred shows that patients who are disoriented are at greatest risk of

TABLE 2 Characteristics, circumstances and consequences of the falls

Cases: *n* = 185	*n* (%)
Nursing shift when fall occurred	
Morning	33 (17.8)
Afternoon/evening	41 (22.2)
Night	111 (60)
Presence of handrails	
No handrail	114 (61.6)
One handrail	21 (11.4)
Two handrails	50 (27)
Accompaniment	
Unaccompanied	142 (76.8)
Accompanied	43 (23.2)
Mechanical restraints	
Yes	31 (16.8)
No	154 (83.2)
Consequences	
Bruising	20 (10.8)
Wound not requiring stitches	19 (10.3)
Wound requiring stitches	5 (2.7)
Fracture	1 (0.5)
No consequences	140 (75.7)

TABLE 3 Association between every plasmatic chemical results and fall events

	p	OR*	95% CI
Hyponatraemia	.001	2.04	1.35–3.09
Hypercreatinaemia	<.001	2.49	1.61–3.85
Hyperkalaemia	.366	1.32	0.72–2.39
Hyperuraemia	.002	1.82	1.24–2.68

*Odds Ratio (OR) are adjusted by type of unit, age and gender.

suffering an in-hospital fall. These results are in line those presented in a systematic review of risk factors for in-hospital falls, which concluded that cognitive impairment was significantly related to this risk (Deandrea et al., 2013). The situation is similar for ambulatory ability: thus, patients who required assistance to walk suffered 91.4% of the falls recorded. This finding shows that the persons most affected by falls are those who suffer a slight deterioration in their ability to walk, one that does not completely prevent ambulation, but makes it difficult. Deandrea reported an OR = 2.2 for falls by patients who required walking assistance (Deandrea et al., 2013). Both results (disorientation and the need for ambulatory assistance) are in line with a systematic review that places impaired balance and gait and cognitive decline among the main risk factors for falls (Ambrose et al., 2015).

Average hospital stays vary significantly depending on the unit, the patient's condition and other factors. In our study, the cases were hospitalised, on average, for 10 days longer than the controls. This disparity has also been described in a recent research, with a median length of stay of 35 days for fallers versus 21 days for non fallers ($p < .001$) (Hars et al., 2018). However, this question needs to be examined in greater detail to determine the causes of this increased stay more exactly and to ascertain whether it is due to factors such as greater instability or a poorer clinical prognosis, or whether the greater probability of falling is merely a consequence of being hospitalised for longer.

In routine clinical practice at the hospital where this study was conducted, the patients who are most frail and most at risk of falls are normally situated near the nursing control centre, to enable greater supervision. However, this approach may be impractical when the rooms are distributed among the hospital units. Nevertheless, our results show that the proximity or otherwise of the patient's room to the nursing control centre is not relevant to the chances of their suffering a fall, since most of the falls occurred when the patient was unaccompanied. Furthermore, it is impossible to analyse retrospectively whether the patient's location was intentionally modified by the nurses as a preventive measure, and therefore our results in this respect should be interpreted with caution. Most falls occurred during the night shift, when hospital activity decreases and staff ratios are lower, as has been reported in previous studies in this area (Aranda-Gallardo et al., 2014).

Among the strengths of this study we can mention the sample size, with more than 500 patients analyzed (185 cases and 370 controls). Not only has the relationship between hyponatraemia and falls been explored, but the result of the circumstances and consequences in which these occurred during the study period has been shown. In addition, we have provided information on the relationship between other analytical parameters and falls, which have been very little explored so far, such as hypercreatinaemia and hyperuraemia. With all this, we have contributed to updating the available evidence on an aspect of clinical safety as relevant as the prevention of falls among hospitalized acute patients.

5.1 | Limitations

Given the retrospective nature of this study, some circumstances could not be verified, such as the aforementioned question of whether patients were intentionally relocated during their hospitalisation unit after suffering a fall. The room identified in the digital medical record is the last one occupied by the patient prior to discharge.

Another limitation is the fact that falls may have been underreported in the hospital's computerised record system. For this reason, 27 of the 783 controls initially chosen were later excluded. On the other hand, the possible presence of type 2 error was ruled out by post-hoc analysis, which reflected a statistical power of 80.1% for our study sample.

This study was focused on falls that occurred during the hospital stay. Risk factors such as history of previous falls were not explored. Future studies should incorporate this information due to the importance of this specific risk factor for the occurrence of new falls.

6 | CONCLUSIONS

A strong association was observed between hyponatraemia and the occurrence of in-hospital falls by hospitalised adult patients, in a sample adjusted for age, gender and type of hospital unit, a finding that corroborates previous research in this field. This information could be useful for the development of new instruments for assessing the risk of falls, or for improving the reliability and diagnostic validity of existing measures.

Further research is needed to investigate the causal mechanism of falls by acute-care hospitalised patients with hyponatraemia.

In addition, it would be useful to further investigate the relationship between hypercreatinaemia, hyperuraemia and falls, to overcome the present lack of evidence with which to corroborate our findings.

7 | RELEVANCE TO CLINICAL PRACTICE

The assessment of risk factors for falls, such as hyponatraemia, can alert us to the possibility of this event occurring and facilitate the implementation of preventive measures. This parameter should be included as a significant new factor in assessment instruments designed to assess the risk of falls, thus enhancing the reliability and diagnostic validity of these instruments.

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CONFLICT OF INTEREST

The authors have no conflict of interests to disclose.

AUTHOR CONTRIBUTIONS

Study design: MAG, JMMA; project conduct: MAG, AGL, JIOG, AMB, JCCS; data analysis: AGL, JIOG, JMMA; and manuscript preparation: MAG, AGL, JIOG, JMMA, AMB, JCCS.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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