Factors Associated with Altered Hydration Status among Critically Ill Adult Patients

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Abstract

Maintaining adequate hydration in critically ill patients is primary element of nursing care. However, in critically ill patients, hydration is the missing part of nutritional care and fluid balance disorders are relevant risk factors for morbidity and mortality in those patients. ***Objective:*** *The current study was conducted to identify factors associated with altered hydration status among critically ill patients.* ***Setting:*** *This study was carried out at the intensive care units (ICUs) of the Alexandria Main University Hospital, namely: the casualty care unit and the general intensive care unit.* ***Subjects:*** *A convenience sample of 110 newly admitted critically ill adult patients to the above mentioned settings were included in the current study. Patients on hemodialysis or peritoneal dialysis and those with length of stay <3 days were excluded from this study.* ***Tools****: "Hydration Assessment tool" was used to collect necessary data.* ***Results:*** *The result of current study showed that 68% of the studied sample had fluid volume deficit. The most common factors associated with fluid volume deficit were infection, hyperventilation, impaired skin integrity, unhumidified oxygen therapy, fever, impaired swallowing and hyperglycemia were. While the most common factors associated with fluid volume excess included renal insufficiency and use of steroids medications.* ***Conclusion:*** *Fluid volume deficit is more common than fluid volume excess in the critically ill patients. A significant relationship was found between patients' hydration status alterations and their characteristics. Moreover, it can be concluded that keeping the body well hydrated may seem to be a simple practice. However, it is very difficult, and the assessment of the hydration status in the critically ill patients is challenging.* ***Recommendations:*** *Constant monitoring of fluid intake and output should be done, all factors that contribute to hydration status alterations should be considered and assessed continuously and all markers of hydration should be integrated to identify patients' risk factors for fluid volume deficit or excess.*

Keywords: Hydration; Fluid volume excess; Fluid volume deficit; Critically ill patients.

Introduction

Water is the core nutrient of life and the most abundant component in the body, which is vital for health and life to ensure the correct fluid balance in the body[1,2]. Absence of water can be fatal within days. It is often missing in the inventory of dietary constituents[1,3]. Fulfilling optimal hydration is a fundamental part of holistic patient care[4]. Incident reports about hydration show that this area is neglecting, and recommended for changing practice to decrease the negative effect on the patient outcomes[5].

Critically ill patients are different in terms of illness; many of them experiencing electrolyte abnormalities or fluid imbalances that can compromise their status[5]. Normal fluid balance can be disrupted by illness and it has been proved to be an independent predictor of survival, especially in the first three days of admission[6- 9].

Since hydration plays an important role in the management of critically ill patients[10], monitoring and carefully managing electrolytes and fluids balance is mandatory[5]. It was observed that hydration is neglected and many patients experienced hydration alteration especially fluid volume deficit in ICUs. There are two main factors associated with hydration status alterations including fluid volume deficit and excess factors. Hospitalized patients are at risk for increased sensible and insensible fluid loss via many mechanisms as infection, a febrile condition (38.3^{o}), co-morbidities such as cerebrovascular stroke, diabetes mellitus, deterioration in the level of consciousness, excessive gastrointestinal fluid loss, impaired skin integrity such as pressure ulcers and burn, and those experiencing trauma or sepsis, third-spacing fluid shift. Constipation, hyperglycemia can also result in dehydration over time; urinary tract infections and cerebral infarction are all associated with dehydration[2,7,11].

Fluid volume excess is due to sodium and water retention while, overhydration is due to gaining more water than electrolytes [12]. Factors associated with fluid volume excess caused by fluid retention include chronic heart failure, acute kidney injury, liver cirrhosis or iatrogenic fluid exces[12].

Several multi-center clinical trials have shown a positive correlation between fluid overload and adverse outcomes in the critically ill patients admitted to ICUs[7]. Nutrition and hydration deleterious effects had clinical and financial impact which requires the attention of all healthcare providers[13,14] Poor fluid management and malnutrition are estimated to cost the UK National Health Service over £13 billion a year, a conservative estimate as it does not account for the morbidity that may occur due to malnutrition and poor fluid balance[15]. Ensuring that nutrition and hydration needs of the hospitalized patients are met is a nurse's role[16].

Fluids and electrolytes balance is vital to life and it is clear that many conditions or factors can affect this balance. Hence, this study was conducted.

Aim of the Study

This study aims to identify factors associated with altered hydration status among critically ill adult patients.

Research Question:

What are the factors associated with altered hydration status among critically ill adult patients?

Materials and Method

Materials

Design: A descriptive research design was used in this study.

Setting: This study was carried out at the ICUs of the Alexandria Main University Hospital, namely: the casualty care unit (unit I) and the general intensive care unit (unit III).

Subjects: A convenience sample of 110 newly admitted critically ill adult patients to the above mentioned settings were included in the current study. Patients on hemodialysis or peritoneal dialysis and those with length of stay < 3 days were excluded from this study. The EPI-INFO software was used to estimate the sample size of this study, which revealed a minimum sample size of 110 patients.

Tool:

Tool I: Hydration Assessment Tool

It was developed by the researcher after reviewing the relevant literature. It consists of five parts: **The first part covered** patient's profile data including age, sex, past history and diagnosis. **The second part covered** factors associated with hydration status alterations including factors associated with fluid volume deficit and excess. **The third part covered** patients' physiological parameters record including hemodynamic parameters, ventilation and oxygenation parameters, physical examination and nutritional assessment. **The fourth part covered** patients' metabolic and chemical analysis of hydration record including measured and calculated parameters. **The fifth part** was adopted[17]. **It covered** fluid balance for the four consecutive observation days using the cumulative fluid balance bar chart.

Method

- An official letter from the Faculty of Nursing was taken to the hospital responsible authority to obtain permission to conduct the study after explanation of the aim of the study.
- Tool was developed by the researcher after reviewing the relevant literature
- The content validity of the tool was tested by jury of seven experts in the related fields and the necessary modifications were done.
- Reliability of the tool was measured using Cronbach Alpha reliability, the reliability coefficients were (r=0.9) which is acceptable.
- A pilot study was carried out on eleven adult critically ill patients to test the clarity and applicability of the tools, and the all necessary modifications were done. Appropriate modifications were done prior to the data collection of the study**.**
- Data were collected by the researcher during approximately eight months starting from May 2015 to December 2015.

Data were collected as follows:

- Newly admitted patients who met the inclusion criteria were enrolled in this study and assessed for four consecutive days.
- Patients' demographic data and clinical data were assessed and recorded upon the admission using part I of the tool.
- Factors associated with alteration in the hydration status were assessed and recorded using part II of the tool depends on the measurements and observations done in parts III, VI, V of the tool after the observation periods.
- Hemodynamic parameters were assessed and recorded using part III of the tool for three times (morning, evening, and night shift) for four consecutive days.
- Ventilation parameters were assessed and recorded once every day for four days.
- The base line physical examination and clinical observation for signs of hydration alteration were done within the first 24 hours from admission were repeated daily for four consecutive days.
- Nutritional assessment (anthropometric measurements) was done for the patients as a baseline data in the first day of admission once and then in the fourth day.
- Metabolic and chemical parameters were assessed daily for four consecutive days. It was classified into measured and calculated values.
- Cumulative Fluid balance was monitored using part V.

Ethical considerations:

- The present study was approved by the Scientific Research Ethics Committee of the Faculty of Nursing-Alexandria University.
- Informed written consent was obtained from critically ill patients before conducting the study after explaining the aim of the study and the right to refuse to participate in the study will be emphasized to patients.
- Critically ill patients' anonymity, confidentiality and privacy were maintained during implementation of the study.

Statistical Analysis

Chi-square test and Fisher exact test were used alternatively to test the association between two qualitative variables or to detect the difference between two or more proportions. The 0.05 level or below was used as the cutoff value for statistical significance.

Results

Table (1) represents distribution of the critically ill patients in relation to the demographic and health related data. It was observed that 51% of the studied sample aged between 30 to< 50 years old. Male patients represented the majority of the studied sample. From the same table it was observed that 28.2 % of the studied sample was suffering from neurological disorders while 38.2 % of them had no past history on their admission to the ICU. Moreover, it was observed that more than 68% of the studied sample had fluid volume deficit while only 32% had fluid volume excess.

Table (2) demonstrates factors associated with hydration status alterations. It was observed that the most common factors associated with fluid volume deficit included infection, hyperventilation, impaired skin integrity, unhumidified oxygen therapy, fever, impaired of swallowing and hyperglycemia. While the most common factors associated with fluid volume excess included renal insufficiency and use of steroids medications.

Table (3) shows relationship between the hydration status alterations of the critically ill patients and their characteristics. It was observed that there was a significant relation between patients 'age, and sex and the fluid volume excess. Female and older patients were commonly experienced fluid volume excess and vice versa. It was noticed also a significant relationship between fluid volume excess and patients with history of cardiovascular, respiratory and renal diseases. Moreover, a significant relationship was found between fluid volume deficit and patients with poisoning and neurological diagnoses.

Table (4) shows the relationship between the hydration status alterations of the critically ill patients and the cumulative fluid balance and the insensible loss. A significant relationship was found between patients with fluid volume excess and the cumulative balance (positive balance), while a significant relationship between patients with fluid volume deficit and the insensible fluid loss.

Table (5) indicates relationship between the hydration status of the critically ill patients and the factors associated with its alterations. A significant relationship was found between fluid volume deficit and experiencing fever, malnutrition, constipation, and patients with no oral or enteral feeding. On the other hand, a significant relationship was observed between fluid volume excess and experiencing renal and liver insufficiency.

Table (6) demonstrates relationship between the hydration status alterations of the critically ill patients and the ventilation parameters. A significant relationship was observed between patients with fluid volume deficit and the minute ventilation (increased).

Discussion

Critical illness can cause disturbance in the fluids homeostasis and also threaten fluid balance by therapeutic interventions such as diuretics or nasogastric aspiration [18,19]. The findings of the current study indicated that most of the studied patients had fluid volume deficit and most of them had negative cumulative fluid balance and vice versus, this may be related to presences of many factors that associated with fluid volume deficit such as increase insensible fluid loss, and decrease fluid intake. Health Care Financing Administration documented that dehydration is among the 10th most frequent diagnoses that require hospitalization[20]. In addition, England Care Quality Commission reported that many hospital patients are suffering from dehydration[21]. Contrary to these findings Basso et al. (2013)[8] indicated that the majority of the studied patients were more likely to be overhydrated starting from the 2nd day of observations.

The findings of current study reflected a significant relationship between **fluid volume deficit** and the presence of **fever**. This may be attributed to the presence of infection, which is always considered a primary cause of fever[22]. These may be related to excessive sweating and increased metabolic demand due to increased body temperature leading to fluid loss. The current study findings indicated that more than one half of studied patients had **acquired infection** including blood stream infection, urinary tract infection, and respiratory tract infections. Mild dehydration might possibly confirm its role in the pathogenesis of UTI[23]. Moreover, the presence of a foley catheter which is the most frequent device used in the ICU can lead to infection [24]. these results are supported by Campbell (2014)[25] who reported that insufficient water intake leads to dehydration, which is the underlying cause of many common conditions including constipation; urinary tract infections; pressure ulcers; and malnutrition.

Humidified inspired gas in a ventilated ICU patient can decrease the insensible loss. The current study findings indicated that most of the studied patients were not attached to the **air humidifier**. This result is supported by Adel (2015)[26] who found that all nurses didn’t provide humidified oxygen.

The current study findings indicated that some of the studied patients had **fluid volume loss** due to **third space losses**. This may be related to that third space syndrome which is confusing in the ICU as it is difficult to detect, where the ICU patients were intravascularly depleted while extravascular overloaded. It is commonly caused by inflammation, malnutrition, low albumin and protein level, history of renal or liver failure, capillary leak in sepsis and burns. This result is supported by Culleiton (2011)[5] who reported that critically ill patients can be dehydrated while appearing be overloaded, they related this to that fluid accumulated in the extravascular space is physiologically useless due to malnutrition, and low albumin.

The results of the current study revealed that most of the studied patients were unable to express thirst and impaired swallowing which decrease their fluid intake. This may be related to the disturbed level of consciousness because of patients' diagnosis and or excessive using of sedation in our ICUs. In addition, most of patients were attached with oral endotracheal and nasogastric tube caused lack of non verbal communication. These results is in agreement with Palmer et al. (2000)[27] who found that swallowing disorders are common and may cause aspiration, dehydration, pneumonia, and weight loss due to impaired control of the tongue.

Medications also associated with fluid volume deficit because of the **proton pump inhibitors, diuretics and laxatives**. It was documented that the **proton pump inhibitors** used commonly for stress ulcers prophylaxis but its side effects including nausea, constipation, increase risk for infection with clostridium difficile colitis and aspiration which can affect on fluid intake and loss[28]. This finding is in agreement with Chiba (2013)[29] who found that proton pump inhibitors affect the hydration status due to its side effects that include diarrhea and serious effects of rebound acid hypersecretion as intestinal perforation and dehydration.

The result of current study revealed that **diuretics** are used in the majority of studied patients. This may be indicated to remove excess fluids in case of congestive heart failure, ascites, and renal failure. This result is in line with Louis (2010)[30] who found that **diuretics** can cause overall fluid depletion.

Constipation also is one of the most common findings in ICU patients which can be consequence of altered of hydration status. The current study findings indicated that some of the studied patients were constipated throughout the observation days. This may be related to the immobility, lack of water access, inadequacy of dietary intake formula commonly used milk, fruit juice, and inconsistency feeding formula that can obstruct the gastric tube and interrupt enteral feeding. In addition, adverse effects of using laxative in those patients such as fluids and electrolytes imbalances.

This result is supported by Vivanti et al. (2007)[31] who stated that increase significant risk for dehydration among patients who receive laxative. Yet, the critical care nurses should take in consideration that constipation in critically ill patients is not a benign condition and it could lead to weaning failure , increase length of ICU stay and it can cause mild dehydration.

The current study findings show that most of the studied patients used **iso-osmolarity** and some of them used **hyper osmolarity** infusions throughout the observations days. **Hyperosmolarity infusions** used include mannitol especially in traumatic patients to manage increase of intracranial pressure. Hyperosmolarity solution caused volume depletion and hypernatremia by osmotic diuretic and increasing urinary losses of both sodium and water as indicated by results of lab investigations. In very high doses of mannitol, it could be retained in the circulation causing fluid volume excess[32]. The current study finding is supported by Myburgh (2015)[33] who found that the excessive use of intravenous fluids during the resuscitative period is associated with increased cumulative fluid balance.

The current study findings is supported by Payen et al. (2008)[34] who found that additional fluid therapy for optimal hemodynamics and restoration of intravascular volume caused failure to improve kidney function, unnecessary fluids accumulation and impaired gas exchange. Moreover, Bagshaw et al 2008 [35] stated that critically ill patients can receive variable amounts of fluid therapy during critical illness by the first 72 hours from 13 to 14 liters may lead to fluid overload.

Fluid retention and dehydration are both complications from **mechanical ventilation**[36]. The findings of current study revealed that most of the studied patients attached to the mechanical ventilator. A significant relationship between hydration status alterations and fluid volume deficit was found in relation to minute ventilation. This may be interpreted that the most of them had increase respiratory rate caused increase insensible fluid loss. On the other hand, Positive pressure ventilation caused **fluid volume excess** among the studied patients, this may be related to the effect of positive pressure ventilation on the cardiac function that result in increase the mean intrathoracic pressure, increase afterload and decrease cardiac output. In addition, renal impairment that lead to sodium and water retention[37]. This is supported by Hassan (2008)[38] who found that positive pressure ventilation had effect on venous return in critically ill patients attached to mechanical ventilator.

Other factor associated with fluid volume excess was found in current study that indicated some of the studied patients used steroids. **Steroids** used as an anti inflammatory which may cause inhibition in the prostaglandin formation that can lead to fluid retention**.**

The current study findings reveal a significant relationship between the hydration status alterations of the studied patients and their characteristics including age, sex, past history and diagnosis. The older studied patients were commonly experienced fluid volume excess. This may be related to older patients may suffer from impairment of kidneys function. On the other hand, young studied patients were commonly experienced fluid volume deficit due to trauma and disturbance of sensorium. This result is supported by Tai et al.

(2014)[39] who found that the fluid balance between intracellular and extracellular water changes with age.

The current study finding indicated that **females** studied patients were commonly experienced **fluid volume excess.** This may be attributed to the sex hormone such as estrogens or progesterone that may impact the physiological function through regulation of the body fluids and sodium content. In contrast, Kadri (2013)[40] found that sodium imbalances are particularly important in the ICU patients associated with increased mortality **regardless** of age, gender and diagnoses.

Findings of current study demonstrated a significant relationship between **fluid volume excess** and **history** of the **cardiovascular**, **respiratory** and **renal** diseases. Old age patients admitted with renal or cardiac problems associated with past medical or surgical history. This may be related to **chronic illness** such as diabetes mellitus, renal impairment, and liver cirrhosis can increase risk for fluid volume **accumulation** and **excess** by pumping failure, cor-pulmonale condition, and impaired of renal function. This result is supported by Tai et al et. (2014)[39] who found that increase extracellular volume status was tended to be associated with older age, diabetes mellitus, resistant hypertension, lower renal function, lower serum albumin levels, and higher protein uria levels.

The current study finding revealed a significant relationship between the **fluid volume deficit** and the patients with **neurological diagnoses.** This may be related to the **traumatic causes** such as spinal cord injuries and traumatic brain injuries which is one of the neurological disorders that may cause profuse blood loss with underestimation of the blood loss leading to hypovolemic shock and inappropriate fluids management. Moreover, **stroke** can increase the risk for fluid volume deficit due to impaired of swallowing and disturbed level of consciousness that may lead to inability to express thirst and impaired access to water.

A significant relationship was found also between the **fluid volume deficit** and the patients with **poisoning diagnoses. Poisoning** was commonly occurred among young studied patients due to the intake of unknown substances accidently or suicidal attempts. This will increase the risk for fluid volume deficit due to **diagnostic and therapeutically** measurements such as nasogastric lavage, oral intake restriction, lack of water flushing, and use of activated charcool. **Activated charcool** can lead to complications such as hypernatremia and hypermagnesemia which decreased the levels of consciousness. Therefore, the critical care nurses should take into considerations the history and diagnosis of the patients in hydration assessment to identify risks for fluid volume deficit or excess.

This result was supported by Musaa et al. (2013)[41] who indicated that malnutrition is related to the dehydration. Further, Niemann (2012)[42] reported that body weight change can be a reliable assessment of hydration status.

Conclusion

Based on the findings of this study, it can be concluded that fluid volume deficit is more common than fluid volume excess in the critically ill studied patients. In addition to, presence of significant relationship between patients' hydration status alterations and their age, sex, past medical, surgical history, and patients' diagnosis. Also it can be concluded that keeping the body hydrated may seem to be a simple practice but it is very difficult and assessment of the hydration status in the critically ill patients is challenging and combinations between hemodynamic (vital signs and CVP values); physical manifestations (oral cavity, urine, weight changes); and haematological markers (haemoglobin, haematocrit, BUN: creatinine ratio, and serum osmolarity) is needed to be used to determine the risk for hydration status alterations.

Recommendations

In light of the current study findings, the following recommendations are suggested:

- Constant monitoring of fluids intake and output including the insensible fluid losses should be done.
- All factors that contributing to hydration status alterations should be considered and assessed continuously.
- Enteral tube flushing should be done before and after feedings or medications. Humidified oxygen should be used for critically ill patients in ICUs.
- In services training programs for the critical care nurses regarding importance of hydration, adverse events of the hydration status alterations should be conducted.

Table (1): Distribution of the critically ill patients in relation to the demographic and health related data

Demographic and health related data (n = 110)						
Demographic data	**Age**	**No**	**%**	**Sex**	**No**	**%**
	< 30 years	26	23.6	Male	61	55.5
	≥- 30 < 50	56	51	Female	49	44.5
	≥51 - < 60 years	28	25.0			
	Min. – max.	16.0 – 59.0				
	Mean ± SD	40.37 ± 12.760				
Health related data	**Patient's diagnosis**	**No**	**%**	**History**	**No**	**%**
	Neurological	31	28.2	NO history	42	38.2
	Respiratory	25	22.7	Cardiovascular	26	23.6
	Poisoning	21	19.2	Respiratory	15	13.6
	Cardiovascular	20	18.1	Neurological	8	7.2
	Renal	8	7.3	Gastrointestinal	8	7.3
	Gastrointestinal	5	4.5	Renal	9	8.3
				Surgery	2	1.8
	Hydration status alteration			**APACHE II score on admission**		
	Fluid volume deficit	75	68.2	42± 39		
	Fluid volume excess	35	31.8			

Table (2): Distribution of the critically ill patients according to the factors associated with the hydration status alterations

Factors associated with hydration status alterations (N= 110)							
Factors associated with fluid volume excess (n= 110)							
Pathological		**N**	**%**	**Therapeutic**		**N**	**%**
Renal insufficiency		13	11.8	Dialysis		3	2.7
Cardiac instability		10	9.1	Steroid		16	14.5
Liver insufficiency		8	7.3				
Factors associated with fluid volume deficit	**Factors affect fluid loss**	**Factors affect insensible loss**				N	%
		Infection				76	83.6
		Hyperventilation				64	58.2
		Impaired skin integrity				63	58
		Unhumidified Oxygen therapy				63	58
		Fever				53	48.2
		Tracheostomy				14	12.7
		Massive burn				0	0.0
		Factors affect sensible fluid loss					
		Third space loss				19	17.3
		Hyperglycemia				62	56.4
		Malnutrition				19	17.3
		Chemo/radiotherapy history				5	4.5
		Gastrointestinal (GIT) Loss				33	30
		Upper GIT loss				27	24.5
		NG drainage				22	20.0
		Vomiting				4	3.6
		Hematmesis				1	0.9
		No				83	75.5
		Lower GIT loss				6	5.4
		Diarrhea				5	4.5
		Hematochezia				0	0.0
		Melena				1	0.9
		No				104	94.5
	Factors affect fluid intake	Impaired swallowing				77	70.0
		Constipation				36	32.7
		NPO status				48	43.6
		Less than or equal 24 hours				29	26.4
		48 hours				6	5.5
		More than 48 hours				13	11.8
		No				62	56.4
		Therapeutical					
		Proton pump inhibitors				65	59.1
		Laxatives				33	30.0
		Diuretics				25	22.7
		Type of intravenous infusion					
		Hyper-osmolarity				51	46.4
		Iso- osmolarity				102	92.7
		Hypo- osmolarity				9	8.2

Table (3): Relationship between the hydration status alterations of the critically ill patients and their characteristics

Patients characteristics		Hydration status alterations (N= 110)				Test of significant	P
		Fluid volume deficit (N=75)		Fluid volume excess (N=35)			
		N.	%	N.	%		
Age	<30	24	32.0	2	5.7	9.464^{*}	0.024^{*}
	30 – 40	18	24.0	10	28.6		
	41 – 50	17	22.7	11	31.4		
	>50	16	21.3	12	34.3		
Sex	Male	48	64.0	13	37.1	6.968^{*}	0.008^{*}
	Female	27	36.0	22	62.9		
History							
No history		33	44	3	8.5	9.572^{*}	0.002^{*}
Cardiovascular		16	21.3	10	28.5	13.899^{*}	$<0.001^{*}$
Respiratory		15	20.	6	17.2	0.056*	$^{FE}p=0.053^{*}$
Neurological		5	6.6	3	8.6	0.054	0.817
Gastrointestinal		4	5.3	4	11.4	0.014	$^{FE}p=1.000$
Renal		1	1.3	8	22.9	14.716^{*}	$^{FE}p=<0.001^{*}$
Surgery		1	1.3	1	2.9	0.310	$^{FE}p=0.537$
Patient' s diagnosis							
Neurological		27	36	4	11.4	4.769^{*}	0.029^{*}
Poisoning		18	24	3	8.7	3.678	0.055^{*}
Respiratory		16	21.3	8	22.7	0.261	0.610
Cardiovascular		10	13.3	11	31.5	5.059^{*}	0.025^{*}
Renal		3	4.0	5	14.3	3.744	$^{FE}p=0.107$
Gastrointestinal		1	1.4	4	11.4	2.210	$^{FE}p=0.206$

χ^2: Chi square test FE: Fisher Exact for Chi square test * statistically significant at $p \leq 0.05$

Table (4): Relationship between the hydration status alterations of the critically ill patients and the cumulative fluid balance and insensible loss

Cumulative fluid balance and insensible loss			Observation days								Sig.1
			First		Second		Third		Fourth day		
			No	%	No	%	No	%	No	%	
Cumulative fluid balance											
Negative balance	FVD	n= 75	49	65.3	50	66.7	51	68.0	50	66.7	
	FVE	n= 35	10	28.6	3	8.6	4	11.4	3	8.6	FVD MH= 0.796
Balance	FVD	n= 75	0	0.0	1	1.3	1	1.3	0	0.0	
	FVE	n= 35	0	0.0	0	0.0	0	0.0	0	0.0	
Positive balance	FVD	n= 75	26	34.7	23	30.7	23	30.7	26	33.3	FVE MH= 0.020*
	FVE	n= 35	25	71.4	32	91.4	31	88.6	32	91.4	
Sig2 ^{MC}			<0.001*		<0.001*		<0.001*		<0.001*		
Insensible loss											**Sig_1^t**
Mean±SD	FVD	n= 75	1114.93±283.45		1281.29±369.63		1281.29±369.63		1280.91±323.27		<0.001*
	FVE	n= 35	1033.5 ± 309.12		1121.43±181.76		1132.0±224.76		1145.69±235.69		0.089
Sig_2 χ^2			0.176		0.017*		0.012*		0.015*		

p_1: p value for comparing between 1^{st} reading and last reading *: Statistically significant at $p \le 0.05$ MC: Monte Carlo for Chi square test p2: p value for comparing between the two studied groups tp_1: p value for Paired t-test for comparing between 1^{st} reading and last reading MH: Marginal Homogeneity Test χ^2: Chi square test

Table (5): Relationship between the hydration status of the critically ill patients and factors associated with its alterations

Factors associated with hydration alteration		Hydration status alterations (n= 110)				Test of significant χ^2	Sig.
		Fluid volume deficit (N=75)		Fluid volume excess (N=35)			
Factors associated with fluid volume deficit							
Factor affect fluid loss		**N.**	**%**	**N.**	**%**		
Factors affect insensible loss							
Occurrence of infection	Yes	50	66.7	26	74.3	0.649	0.421
	No	25	33.3	9	25.7		
Hyperventilation	Yes	46	61.3	18	51.4	0.962	0.327
	No	29	38.7	17	48.6		
Fever	Yes	41	54.7	12	34.3	3.970*	0.046*
	No	34	45.3	23	65.7		
Tracheostomy	Yes	10	13.3	4	11.4	0.078	^{FE}P=1.00
	No	65	86.7	31	88.6		
Massive burn	Yes	0	0.0	0	0.0	0.00	0.00
	No	75	100.0	35	100.0		
Factors affect sensible fluid loss							
Impaired swallowing	Yes	54	72.0	23	65.7	0.449	0.503
	No	21	28.0	12	34.3		
Hyperglycemia	Yes	42	56.0	20	57.1	0.013	0.910
	No	33	44.0	15	42.9		
Constipation	Yes	29	38.7	7	20.0	3.777	0.052*
	No	46	61.3	28	80.0		
	No	72	96.0	33	94.3		

χ^2: Chi square test
FE: Fisher Exact for Chi square test
MC: Monte Carlo for Chi square test
* Statistically significant at $p \leq 0.05$

Table (6): Relationship between the hydration status alterations of the critically ill patients and the ventilation parameters

Ventilation data / Observation	Days (n= 110)	First day		Second day		Third day		Fourth day		Sig $_{1(p1)}$	First day		Second day		Third day		Fourth day		Sig $_1$
		N	%	N	%	N	%	N	%		N	%	N	%	N	%	N	%	
		Fluid volume deficit patient (n= 75)									Fluid volume excess patient (n=35)								
Mechanical ventilator	YES	68	90.7	67	89.3	64	85.3	62	82.7	McN = 0.180	34	97.1	32	91.4	31	88.6	29	82.9	McN = 0.063
	NO	7	9.3	8	10.7	11	14.7	13	17.3		1	2.9	3	8.6	4	11.4	6	17.1	
	Sig $_2$ χ^2	0.432		1.000		0.771		1.000			0.432		1.000		0.771		1.000		
Mode	Mandatory	4	5.3	6	8.0	3	4.0	2	2.7	MH = 0.138	3	8.6	2	5.7	1	2.9	2	5.7	MH = 0.095
	Spontaneous	42	56.0	43	57.3	39	52.0	38	50.7		20	57.1	18	51.	18	51.4	16	45.7	
	Mixed	23	30.7	19	25.3	22	29.3	22	29.3		11	31.4	13	37.	12	34.3	11	31.4	
	Sig$_2$ χ^2	0.727		0.673		0.950		0.851			0.727		0.673		0.950		0.851		
Minute ventilation	≤6 (ml/min)	0	0.0	1	1.4	3	4.5	4	6.2	McN = 0.125	5	14.7	4	12.	5	15.6	4	11.4	McN = 1.000
	>6 (ml/min)	70	100.	69	98.6	64	95.5	61	93.8		29	85.3	29	87	27	84.4	26	74.3	
	Sig$_2$ χ^2	0.003*		0.035*		0.01*		0.01*			0.003*		0.035*		0.01*		0.01*		
PEEP*	≤5 cmH2o	49	71.0	46	65.7	45	67.2	39	60.0	McN = 0.238	22	64.7	18	54.5	19	61.3	18	62.1	McN = 1.000
	>5 cmH2o	20	29.0	24	34.3	22	32.8	26	40.0		12	35.3	15	45.5	12	38.7	11	37.9	
	Sig$_2$ χ^2	0.651		0.286		0.650		1.000			0.651		0.286		0.650		1.000		
Humidification	Yes Standard humidifier	9	12.0	9	12.0	15	20.0	11	14.7	MH = 0.473	6	17.1	9	25.7	8	22.9	8	23.5	MH = 0.258
	Yes HHME humidifier	4	5.3	5	6.7	7	9.3	5	6.7		3	8.6	4	11.4	4	11.4	2	5.9	
	Room air	5	6.7	4	5.3	2	2.7	3	4.0		0	0.0	0	0.0	0	0.0	1	2.9	
	No	57	76.0	57	76.0	51	68.0	56	74.7		26	74.3	22	62.9	23	65.7	23	67.6	
	Sig$_2$ χ^2	1.000		0.385		0.123		0.752			1.000		0.385		0.123		0.752		

p: p value for or comparing between 1st reading and last reading   McN: McNemar test   MH: Marginal Homogeneity Test

Sig$_2$ p value for comparing the two groups χ^2: Chi square test   *: Statistically significant at $p \leq 0.05$ *PEEP: positive end expiratory pressure

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