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Modification of Fluid Balance Chart for Nurses to Monitor Fluid Volume Disturbance in Patients Undergoing Hematopoietic Stem Cell Transplantation

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Abstract
Background: Hematopoietic stem cell transplantation involves the intravenous infusion of autologous or allogeneic stem cells to reestablish hematopoietic function in patients whose bone marrow or immune system is damaged. **This study** aimed to modify the fluid balance chart for nurses to monitor fluid volume disturbance in patients undergoing hematopoietic stem cell transplantation. **Design:** A prospective, single - centered research design was utilized in this study. **Setting:** The study was conducted at the Bone marrow transplantation unit at South – Egypt Cancer Institution. **Subject:** A purposive sample of 25 adult conscious patients undergoing stem cell transplant, from both sexes and age range between (20 – 65years).**Tools:** three tools were used**;** a structured interview questionnaire, modified fluid balance chart, and a fluid volume disturbance monitoring sheet. **Results:** There was a statistically significant difference between the modified and routine fluid charts regarding the mean amount of daily fluid balance (10750.00 ± 409 ml) and (8333. 63 ± 388 ml) respectively with (P.value = 0.001). **Conclusion:** modification of fluid balance chart has a great effect on accurate monitoring of the fluid intake, output, and fluid volume disturbances**.**

***Keywords: Chart, Disturbances, Fluid Balance, Nurses & Modification*.**

Introduction
Hematopoietic stem cell transplantation (HSCT) is the transplantation of multipotent hematopoietic stem cells, usually derived from bone marrow, peripheral blood, or umbilical cord blood. It may be autologous (the patient's stem cells are used), allogeneic (the stem cells come from a donor), or syngeneic (from an identical twin) **(Mahla, 2016).** It is most often performed for patients with certain cancers of the blood or bone marrow, such as multiple myeloma or leukemia. Stem cells are later thawed and reinfused into the patient after the conditioning regime, to allow the immune reconstitution **(Alois, et al., 2015).**

It is most often performed for patients with a variety of acquired and inherited malignant and nonmalignant disorders. These include hematologic malignancies (e.g., leukemia, lymphoma, and myeloma), nonmalignant acquired bone marrow disorders (e.g., a plastic anemia), and genetic diseases associated with abnormal hematopoiesis and function (e.g., thalassemia, sickle cell anemia, and severe combined immunodeficiency) **(Stephen, et al., 2015).**

In hematopoietic cell transplantation, patients are given very high doses of chemotherapy or radiation therapy, which is intended to kill cancer cells that may be resistant to more standard doses of chemotherapy. After the treatment, patients must have a healthy supply of stem cells reintroduced, or transplanted. The transplanted cells then reestablish the blood cell production process in the bone marrow **(Robert & Negrin, 2018).**

The cells that will be transplanted can be taken from the bone marrow (called a bone marrow harvest), from the bloodstream (called a peripheral blood stem cell collection, which requires that patients take medications to boost the number of hematopoietic stem cells in the blood), or occasionally from blood obtained from the umbilical cord after the birth of a normal newborn (which are stored in umbilical cord blood banks) **(Park et al., 2017).**

After patients being treated with high-dose anticancer drugs and/or radiation, they receive the stem cells through an intravenous (IV) line like a blood transfusion. This part of the transplant takes 1 to 5 hours. After entering the bloodstream, the stem cells travel to the bone marrow, where they begin to produce new white blood cells, red blood cells, and platelets in a process known as "engraftment." Engraftment usually occurs within about 2 to 4 weeks after transplantation. It can be observed by checking blood counts frequently **(Jeevani, 2011).**

After that, patients exposed to high risk of transplant-related morbidity and mortality and severe post-transplant complications such as increase central venous pressure records (C.V.P), vomiting, fluid overload, pitting edema, or dehydration **(Khan & Heywood, 2010).** Diarrhea, nausea, and vomiting in

the later phase may be due to other potential etiologies including upper gastrointestinal infection; diarrhea occurs in almost half of patients receiving high doses of chemotherapy and radiotherapy. It most commonly occurs within the first 2 weeks after the transplantation **(Tuncer & Rana, 2012).**

So, it is an important issue to monitor the intake and output for those groups of patients. The fluid balance chart has been a document in the healthcare system for over 50 years and is a non-invasive tool to assess the hydration status of patients. It is a chart that documents patients' water input and output in 24 hours. This information is used to inform clinical decisions (such as medication and surgical interventions) from medical staff, nurses and dieticians, who all expect accurate figures in exact measurements **(McGloin, 2015).** All fluid intake and output, whatever the source, must be documented using quantifiable amounts. Also, how frequently the fluid balance chart data– such as hourly or two hourly – should be documented **(Jeyapala et al., 2015).**

Significance of the study

From the researcher's experience during the working at bone marrow transplantation unit, the researcher observed that most of the patients who performed stem cell transplant complicated with fluid overload, increased C.V.P record, or fluid volume deficit (dehydration) due to inaccurate monitoring of fluid intake and output. In 2017, (15 cases) stem cell transplantation process was performed in the bone marrow transplantation unit **(South-Egypt Cancer Institution statistical records, 2017),** most of the cases suffered from fluid volume deficit due to diarrhea, vomiting or pulmonary edema due to fluid overload. Modifying the fluid balance chart is considered an important step during stem cell transplantation and any mistake at the calculating process leads to different complications increases the length of hospital stay, increases the economic cost. So, it is important to modify the fluid balance chart to accurately monitor any fluid disturbances.

Aim of the study

The study aimed to modify the fluid balance chart for nurses to monitor fluid volume disturbance in patients undergoing hematopoietic stem cell transplantation

Hypotheses

H1: The modified fluid balance chart will have a positive effect on monitoring fluid volume disturbance than the routine fluid chart for patients undergoing hematopoietic stem cell transplantation.

H2: patients' weight pre-transplant period (previous weight) will be different from the patients' weight post-transplant period (actual weight).

H3: Fluid volume disturbances and complications will be detected by the modified fluid chart rather than the routine fluid chart.

Patients and methods

Research design: Prospective, single - centered research design was utilized in this study.

Setting: Bone marrow transplantation unit at South – Egypt Cancer Institution at Assuit University Hospital.

Sample: A purposive sample of 50 adult conscious patients undergoing stem cell transplant, from both sexes and their age range between (20 – 65 years) and had an adequate liver function, but because of the decreased flow of patients and patients who died during the transplantation process the researchers deceased the number of study patients to 25.

Sample size

The sample size was determined statistically by power analysis. The calculation was done considering the following: type I error with significant level (α) = 0.5, type II error by power test (1-B) = 80%.It was found that the minimum sample size was 45 patients.

Tools

Tools were developed by the researcher based on the review of the relevant literature for data collection.

The tool I: A structured interview questionnaire: it was developed by the researcher to assess patients' demographic and medical data. It will be divided into two parts:

Part 1: patient's demographic characteristics include: Patient's name, age, gender, Hospital number, date of admission, date of discharge, level of education, occupation, and residence area.

Part 2: Medical date includes: - medical diagnosis, laboratory tests such as (Serum creatinine, Serum urea), weight on admission, capillary refill time, skin elasticity, C.V.P measurement, phlebitis score, and central venous catheter length.

Tool II: ***Modified fluid balance chart:-***it was modified by the researcher to assess the intake and output, it consisted of two parts

Part I: Fluid intake assessment: it consists of two categories; oral intake (by mouth and nasogastric tube (NGT) and Intravenous Intake which includes two lines: - the first line used to infuse (TPN + I.V fluid and additive electrolytes) and the second line used to infuse (Medications and blood component transfusion).

Part II: fluid output assessment: include assessment of urine, stool, vomiting, diarrhea, suctioning, and the insensible loss).

Tool III: Fluid volume disturbance monitoring sheet

This tool was developed by the researcher based on the review of the relevant literature to monitor fluid volume disturbances as diarrhea, vomiting, dry

mucous membrane, hypotension, hypertension, electrolyte disturbances, acid-base disturbances, pulmonary edema, or dehydration.

Administrative approval

Official permission to conduct the study was obtained by the researcher from the director of South –Egypt Cancer Institute, bone marrow transplantation unit. The study tools were tested for content validity by five academic medical and nursing staff from the faculty of nursing at Assuit University. Modifications were done accordingly and then the tools were designed in its final format and tested for reliability using Cronbach's alpha (tau-equivalent reliability) coefficient for tools (I, II, and III) (r= 0.717, 0.884, and 0.73 respectively).

Ethical considerations

All research ethics principles were fulfilled according to the **Helsinki Declaration (1996).** Oral permission for voluntary participation obtained from the patient and the nature and purpose of the study was explained. The researcher initially introduced himself to all patients and they were assured that the collected data would be confidential. Patients were informed that participation is voluntary and that they could withdraw at any time of the study. The confidentiality of the patient's data was ascertained. The patient's names were coded for data entry so that their names could not be identified.

Pilot study

A pilot study was conducted on 10% of the study sample in a selected setting to evaluate the applicability & clarity of the tools. According to this pilot study, the required modifications were made. Those patients who were involved in the pilot study were not included in the study.

Data collection

Data were collected from January 2019 to December 2019. The data collection was done through the following phases:

Assessment phase

In this phase, the researcher designed a new fluid chart by collecting all relevant date from the relevant national and international literature focusing on items that help nurses carefully calculate every milliliter of fluid that entered the patients or exit from him. The researcher interviewed the patients who will perform stem cell transplantation to get their oral consent to participate in the study. The selected patient age was ranged from 20 to 65 years old. The purpose of this phase was explained to the patients before the starting of collecting the patient's data.

Implementation phase

- Patients' demographic and medical data were collected by using (tool I).
- During the transplantation process, patients' fluid intake and output were assessed by the researcher using the routine fluid balance chart after that the modified fluid balance chart was applied on the same patient at the same time using (Tool II)
- Monitor the amount of fluid oral intake by measuring the fluids taken by mouth or by nasogastric tube if found.
- Also, intravenous fluid intake was calculated which includes two lines; the first line used to infuse total parentral nutrition (TPN) and intravenous (I.V) fluid and additive electrolytes, and the second line used to infuse medications and blood component transfusion with stem cell package on zero-day.
- The researcher sums the total fluid intake twice daily (every 12 hours).
- The researcher measured the fluid outputs that include urine, vomiting, diarrhea, suction, and insensible fluid loss (600 ml/24hrs) twice daily (every 12 hours).
- The researcher subtracts the total fluid output during the previous 12 hours from the total amount of fluid intake that calculated at the same period to measure the fluid balance.
- The researcher repeats the previous process of measuring the next 12 hours, then calculate the total amount of fluid intake, output, and fluid balance over 24 hours.
- Also, the researcher observes and records in the modified chart the laboratory investigations as serum urea & serum creatinine, C.V.P measurement, capillary refill, skin elasticity, phlebitis score, and central venous catheter length.
- During and after the transplantation process patients were monitored for fluid volume disturbances that may cause by diarrhea, vomiting, or excessive sweating using (tool III), and recording the time of the disorder appearance for early managing of those problems.

Evaluation phase

- The researcher evaluates the effectiveness of applying the modified fluid chart on the accuracy degree in measuring the amount of fluid intake and output compared by using the routine fluid chart daily till the patients' discharge from the unit (mean 10 days of hospital stay).
- The researcher evaluates the effectiveness of applying the modified fluid chart to measure and early detecting and managing the fluid volume disturbances compared with the routine fluid chart.

Statistical design

Data collected and analyzed by computer program SPSS" ver. 20" Chicago, USA. Data expressed as mean, Standard Deviation, number, and Percentage. T. test was used to determine significance for the numeric variable and Chi-square to determine significance for the non-parametric variable.

Results

Table(1): Distribution of demographic characteristics of patients undergoing HSCT (n. = 25).

Variables	N	%
Age (mean)±SD	30.52±10.94	
Sex		
• Male	7	28.0
• Female	18	72.0
Marital status		
• Single	12	48.0
• Married	13	52.0
Educational level		
• Illiterate	2	8.0
• Primary education	8	32.0
• Secondary education.	7	28.0
• High education	8	32.0
Occupation		
• Housewife	9	36.0
• Student	8	32.0
• Employee	4	16.0
• Skilled workers	4	16.0
Residence		
• Rural	16	64.0
• Urban	9	36.0

HSCT= Hematopoietic Stem Cell Transplantation

Table (2): Comparison of the mean amount of daily fluid balance between the modified and routine fluid charts (n. = 25).

Variable		Routine (Mean ±SD)	Modified (Mean ±SD)	P.value
Day	Pre (D-)	1523.63 ±590	3825.00±433	**0.001***
	During (D0)	3250.00±361	2730.00±248	
	Post (D+)	3560.00±215	4150.00±548	
TOTAL		**8333. 63 ± 388**	**10750.00±409**	

*One way anova test used for this table **= high significance at p≤0.01 (*) statistically significant at p ≤ 0.05*

(D-)= pre – transplant period, (D 0) = during transplant and (D+) = after transplant

Table (3): Comparison between previous weight (weight on admission) and Actual weight (weight post-transplant) of patients undergoing HSCT by the modified fluid chart (n. = 25).

Variable	Mean ±SD (kg.)	Minimum	Maximum	P. Value
Actual weight	63.87±18.49	34.53	104.46	0.001**
Previous weight	64.61±18.865	35.60	110.00	

***= high significance at p≤0.01 (*) statistically significant at p ≤ 0.05*

Independent t- test used for this table

Table (4): Relation between modified chart fluid output and skin elasticity for patients undergoing HSCT process N=25.

Modified chart fluid output	Follow up	Skin elasticity			P.v	Pearson Correlation
		Normal (n %)	Abnormal (n %)	Delayed (n %)		
500-<1000cc	Pre	25 (100)	0	0	---------- --	R=0.435** P= 0.001**
	During	0	0	0		
	Post	0	0	0		
1000-<2000cc	Pre	3(12)	0	0	0.02*	
	During	8(32)	0	0		
	Post	7(28)	7(28)	0		
2000-<3000cc	Pre	0	0	0	0.02*	
	During	0	6 (24.0)	0		
	Post	0	7 (28.0)	12 (47)		
More than 3000cc	Pre	0	0	0	0.003**	
	During	0	3 (12)	0		
	Post	0	2(8)	20(80)		

Chi-Square (χ2) test used for this table
(D-)= pre-transplant period, (D 0) = during transplant and (D+) = after transplant
***= high significance at p≤0.01* ** statistically significant at p ≤ 0.05*

Table (5): Relation between fluid output by modified fluid chart and capillary refill for patients undergoing HSCT process N=25.

Output	Time	Capillary refilled			P.v	Pearson Correlation
		1 sec. (n %)	2 sec. (n %)	3and more (n %)		
500-<1000cc	**Pre**	25 (100)	0	0	---------- -	R=0.105* P= 0.015
	During	0	0	0		
	Post	0	0	0		
1000-<2000cc	**Pre**	0	0	0	0.02*	
	During	0	11 (44.0)	0		
	Post	7(28)	7 (28.0)	0		
2000-<3000cc	**Pre**	0	0	0	0.02*	
	During	0	6 (24.0)	0		
	Post	0	7 (28.0)	12 (47)		
More than 3000cc	**Pre**	0	0	0	0.003**	
	During	0	0	3 (12)		
	Post	0	0	22(88)		

Chi-Square (χ2) test used for this table
***= high significance at p≤0.01* ** statistically significant at p ≤ 0.05*

Table 6: Comparison between routine and modified fluid chart related to complications and fluid volume disturbances for patients undergoing HSCT process n =25

Complications and Fluid volume disturbances	Routine		Modified		P.V
	N	%	N	%	
• Dehydration	0	0	2	8.0	0.56 ns
• Diarrhea	2	8.0	8	32.0	0.04*
• Dry mucous membrane	1	4.0	5	20.0	0.102 ns
• Delayed Skin turgor	0	0	10	40.0	0.03*
• Hypervolemia	2	8.0	15	60.0	0.003**
• Hypovolemia	2	8.0	11	44.0	0.03*

Complications and Fluid volume disturbances	Routine		Modified		P.V
	N	%	N	%	
• Pulmonary edema	0	0	4	16.0	0.102 ns
• Hypotension	0	0	2	8.0	0.56 ns
• Tachycardia	0	0	1	4.0	0.771 ns
• Heart attack	0	0	1	4.0	0.771 ns
• Vomiting	2	8.0	14	56.0	0.003**

Chi-Square ($\chi 2$) test used for this table
***= high significance p≤0.01 * statistically significant at p ≤ 0.05 (ns) Not Significant*

Table (1): Illustrates that more than two-thirds of patients (72%) were females; their age mean was (30.52 =10.94) years. Regarding the educational level; nearly one third (32%) of patients have secondary education, and the other third were having high education, only (8%) of patients were illiterates. Regarding occupation; more than one-third of patients were housewives and the other third were students. Regarding residence; more than one-half of patients (64%) lived in rural areas.

Table (2): Illustrates that the mean fluid balance of the routine chart was 8333. 63 ± 388 ml while the mean fluid balance of the modified chart was 10750.00±409 ml. There was a statistically significant difference between the modified and routine fluid charts regarding the mean amount of daily fluid balance with (P.value = 0.001).

Table (3): Demonstrated that there was a difference between patients' weight pre-transplant period (previous weight) from the post-transplant period (actual weight) by approximately (6 kg). So, there was a high statistically significant difference between the previous and actual weight of patients undergoing HSCT by a modified fluid chart with P.value (0.001).

Table (4): Shows that all patients (100%) have normal skin elasticity when their fluid output ranged from 500-<1000 cc, but patients whose fluid output ranged from2000-<3000cc their skin elasticity deteriorated to become abnormal, while the majority of patients (80%) whose fluid output was more than 3000cc have delayed skin elasticity.

Table (5): Show that all patients (100%) have one-second capillary refill when their fluid output ranged from 500-<1000 cc, but patients whose fluid output ranged from 1000-<2000cc and 2000-<3000cc their capillary refill increased to become two seconds, while the majority of patients (88%) whose fluid output was more than 3000cc have three seconds and more of the capillary refill. So, we can report that accurate monitoring of fluid output by using the modified fluid chart has a great effect on discovering any abnormality in fluid volume in the body and dehydration as well.

Table (6): The current table shows the number of patients who have complications and fluid volume disturbances which occurred during the HSCT process by using routine and modified fluid chart. Very serious complications as diarrhea, delayed skin turgor, hypervolemia, hypovolemia, and vomiting were detected by a modified chart rather than the routine chart with statistically significant differences for each item.

Discussion

The hematopoietic stem cell transplantation (HSCT) is characterized as a therapy used to achieve a long period of remission or cure for patients with benign or malignant hematological disorders. It is a long therapeutic process that can be divided into three distinct phases: pre, during, and post-HSCT **(Timuragaoglu, 2017)** & **(Tormey et al., 2015).**

Based on the result of the present study more than two-thirds of HSCT patients were females and more than a quarter of them were males. Patients' age was ranging between thirty to fifty years with mean age (30.52±10.94) years. More than one-half of patients lived in rural areas These findings were agreeing with **Rondon et al., (2017)**, **Nassif et al., (2018)** and **Barba et al., (2016)** who were on the same line as they reported that" the mean age of the study patients was forty three years, but not agreeing with the gender of patients as they clarified that" two-third of patients were male and less than half of them were female". **Xiaopan et al., (2018)**, **Zheng, (2015), Gong, (2018)**, & **Loberiza et al., (2010)** were not in the same line of the study results as they revealed that "more than of one half of patients came from urban areas".

The current study illustrated that the mean fluid balance of the routine chart was 8333. 63 ± 388 ml while the mean fluid balance of the modified chart was 10750.00 ± 409 ml with nearly two liters difference between the two charts. From the researchers' point of view, this result is expected as the nurses didn't accurately calculate the amount of fluid intake and output as (fluids used in flushing the intravenous catheter and the insensible fluid loss) in

the routine fluid chart, it may be because their workload or nurses shortage in the unit but it was calculated on the modified fluid chart, adding to that the nurses' mistakes in calculating and recording the daily balance. **Reid, (2014)** were agreeing with our explanation as they found that a shortage of nursing staff, a deficit in knowledge and a heavy workload are factors affecting fluid balance monitoring in ICU.

These findings agreed with **Diacon & Bell (2017)** who reported that "the majority of recoded fluid balance by critical care nurses was deviated by more than fifty ml from the required balance". Also, **Perren et al., (2011), Gonzalez, & Vincent (2011)** founded that "fluid balance was inaccurate in more than third of critically ill patients with errors ranging from (-3606 mL to +2020 mL)". **Asfour (2016)** who performed a study to assess the accuracy of fluid balance monitoring in critical care units was not agreeing with the previous findings as he reported that "It was observed that more than half of fluid balance recorded in patients" folders were accurate and more than a quarter were inaccurate".

Regarding the Modified chart; the current study showed that there was a difference between patients' weight pre-transplant periods from the post-transplant period by approximately (six kg). From the researchers' opinion, weight loss that occurred during HSCT is because of refusing oral intake by patients and the majority of them had oral mucositis that prevents them from eating adding to that fluid loss from vomiting and diarrhea that occurred during the transplantation period. This result was not similar to **Sangeeta & Hingorani (2017)** who performed a study on kidney injury after HCT, and reported that "weight gain more than two kg. had occurred to patients within the first twenty days post-transplant was a risk factor for the development of acute kidney injury (AKI) requiring dialysis".

The current study clarified that by using the modified chart, all patients have one-second capillary refill when their fluid output ranged from five hundred ml. to less than one liter, but patients whose fluid output ranged from one liter to less than two liters and two liters to less than three liters their capillary refill increased to become two seconds, while the majority of patients whose fluid output was more than three liters have three seconds and more of a capillary refill. So, there is a positive correlation between the amount of fluid output and capillary refill, as the amount of fluid output increases, the time of capillary refill increased.

From the researchers' point of view as capillary refill time calculated by modified fluid chart reflects the degree of dehydration during the transplantation process, so when patients lose more fluid from vomiting and diarrhea for example during and post-transplantation, capillary refill time increased. This result was similar to **Mrgan, et al., (2014*)*** study performed to assess the relation between capillary refill time (CRT) and mortality case on emergency department found a statistically significant association between abnormal CRT and dehydration after twenty four hours. Also, **Jose et al., (2016)** revealed that "increased time for capillary refill two to three seconds due to external/stress-related prolonged physical activity without consuming adequate water".

Additionally, **Lara et al., (2017)** who performed a study titled "Capillary refill time during fluid resuscitation in patients with sepsis-related hyperlactatemia at the emergency department is related to mortality" discovered that dehydrated patients had abnormal CRT and patients with abnormal CRT after initial fluid resuscitation had an increased risk of adverse outcomes and hospital mortality as compared with normal CRT.

The current study showed that by using modified fluid chart, all patients have normal skin elasticity when their fluid output ranged from five hundred ml. to less than one liter, but patients whose fluid output ranged from two liters to less than three liters their skin elasticity deteriorated to become abnormal to delayed, while the majority of patients whose fluid output was more than three liters have delayed skin elasticity. So, we can conclude that there was a positive correlation between the amount of fluid output and skin elasticity, as the amount of fluid output increase, the risk of dehydration increased and the time of returning of skin to its normal site increased (delayed skin turgor).

From the researchers' point of view, it can conclude that skin elasticity can be deteriorated in cancer patients because the received chemotherapy and radiotherapy can increase their vomiting, and diarrhea, which increases their fluid output that increased the patients' risk of dehydration and abnormal skin turgor. This agrees with **Fabbrocini et al., (2017)** who performed a study that assess the effect of chemotherapy on skin turgor, they founded that more than half of patients who had assumed traditional chemotherapy drugs suffered from dry skin and abnormal skin turgor.

The current study revealed that very serious complications as diarrhea, delayed skin turgor, hypervolemia, hypovolemia, and vomiting were detected by a modified chart rather than the routine chart with statistically significant differences for each item.

These results were similar to **Shadi et al., (2016) & Van Kraaij (2017)** who reported that" Diarrhea is a common complication of HSCT, with an average incidence of approximately fifty percent of patients,

with a higher occurrence within the first several weeks post-transplant. Also, **Sangeeta & Hingorani (2017)** who performed a retrospective study on adult HCT patients was agreeing with the study findings and found that more than one-half of study patients suffered from hypervolemia had a significant increase in weight from their baseline within the first week after transplant and also, agree with **Rondón et al., (2017)** who reported that "more than half of patients who performed HSCT complained from post-transplant fluid overload (hypervolemia)".

Also, Johansson et al., (2013) were agreeing with the current study regarding vomiting, diarrhea as they revealed that "oral ulcers, abdominal pains, and diarrhea are symptoms that reflect damage to the entire GI tract together with a disruption of the intestinal barrier function approximately two weeks after the start of the conditioning therapy. Some patients experience nausea and vomiting for up to two months after the transplantation (prolonged post-chemotherapy nausea and vomiting).

Finally, accurate monitoring of fluid intake and output is a crucial part of the management of patients undergoing HSCT, rapid discovering of very serious complications that decrease the patients' morbidity and mortality and improve those patients' outcomes.

Conclusion

- There was a statistically significant difference between the modified and routine fluid charts regarding the mean amount of daily fluid balance with (P.value = 0.001).
- There was a difference between patients' weight pre-transplant period (previous weight) from the post-transplant period (actual weight) by approximately (6 kg) with P.value (0.001).
- There were positive correlations between the amount of modified chart fluid output and skin elasticity& capillary refill time, as the amount of fluid output increase, the risk of dehydration increased and the time of capillary refill increased and returning of skin to its normal site increased (delayed skin turgor).
- Very serious complications as diarrhea, delayed skin turgor, hypervolemia, hypovolemia, and vomiting were detected by a modified chart rather than the routine chart with statistically significant differences between them.

Recommendations

- Application of the modified fluid chart in monitoring the fluid intake, output, and fluid volume disturbances in HSCT patients.
- Sufficient information about signs and symptoms of the potential complications due to fluid volume disturbance should be provided to all nurses who deal with HSCT patients.
- Providing nurses with continuous education courses about accurate monitoring of fluid intake and output using the modified chart.
- A similar study should be replicated using a large sample and in more geographical areas so that findings can be generalized for a large population.

Difficulties of the study

- **Decreased Sample size**: as it was planned to perform the research on 50 patients but because of the decreased flow of patients and patients who died during the transplantation process the researchers deceased the number of study patients to 25.
- **Lack of prior research studies on the topic**: that explains the cause of choosing the exploratory research design in carrying out this research in addition to lacking the available references that support or disagree with our findings and writing the review of literature as well.

Applicability of the paper

This paper is very useful and applicable for all oncology, medical, and surgical patients especially those patients who receive a large amount of fluids, overcrowded units as it organized for documenting every amount of fluids that decreases the incidence of forgetting or mistakes in calculation done by nurses.

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