Oral Hydration 1 Hour After Extubation Is Safe And Effective In Cardiac Surgery Patients: A Randomized Trial

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Abstract

Background: Cardiac surgery patients are at a risk of postoperative nausea, vomiting, and aspiration pneumonia, but conventional 4–6-h fasting can exacerbate thirst. Early oral hydration is recommended, but the post-extubation time for intervention remains unclear. This study aimed to investigate the effects of early thirst management on thirst, the oral environment, gastrointestinal adverse reactions, and aspiration pneumonia in cardiac surgery patients.

Methods: A total of 84 cardiac surgery patients were randomly divided into two groups for either conventional oral hydration or early oral hydration. The primary outcome was thirst intensity. The secondary outcomes were adverse gastrointestinal reactions (nausea and vomiting), aspiration pneumonia, unstimulated saliva flow rates, salivary pH, oral odor, oral mucosal moisture, and patients' satisfaction. At 1 h post-extubation, patients were evaluated for thirst intensity and intervention readiness. Patients who passed the evaluation were subjected to thirst management.

Results: The patient demographic and clinical characteristics did not significantly vary between the groups. The scores for thirst (3.38 versus 8.24，F=306.21, P＜0.001), oral mucosa (2.03 versus 3.90, P＜0.001), halitosis (2.77 versus 3.76, P＜0.001) were significantly lower in the early oral hydration group than in the conventional oral hydration group. The early oral hydration group was associated with significantly higher salivary pH (6.44 versus 0, P＜0.001), unstimulated saliva flow rates (0.18 versus 0, P＜0.001) and patient satisfaction (4.28 versus 3.15, P＜0.001) than the conventional oral hydration group. Gastrointestinal adverse reactions did not significantly vary (7.70% versus 4.88%, P=0.60), and aspiration pneumonia was not observed in both groups.

Conclusion: The early oral hydration significantly alleviated thirst, stabilized the oral environment without exacerbating gastrointestinal adverse reactions and aspiration pneumonia, and increased patient satisfaction.

Trial registration: Chinese Clinical Trial Registry: ChiCTR2100049206. Registered 25 July 2021.

Introduction

Economic and social development is associated with lifestyle changes leading to an annual increase in the incidence of cardiovascular diseases, which are increasingly affecting younger adults [1–2]. Currently, surgical procedures are a major treatment option, with approximately 313 million cardiac surgeries being performed annually [3]. Postoperative mortality has been substantially reduced due to the in-depth understanding of heart diseases by cardiac surgeons, the increasing advancements in surgical methods, and the improvements in postoperative monitoring technology. However, patients still suffer from various serious complications. Due to strict fluid intake control measures, thirst caused by insufficient blood volume has emerged as one of the most common distress-related chief complaints from patients after cardiac surgery [4]. Ford et al. [5] found that 6 h post-extubation, approximately 90.6% of cardiac surgery patients complained of thirst, and 81.2% of the patients experienced severe thirst. Moreover, adverse

consequences can be triggered without timely thirst relief. Thirst discomfort can cause oral dryness and changes in the oral environment, further resulting in reduced saliva secretion, reduced saliva pH, and dysbiosis of oral microbiota, which is accompanied by bad breath, pharyngeal discomfort, and retrograde lung infection [6]. In severe cases, patients can experience an enhanced stress response, increased oxygen consumption and metabolic burden, and negative emotions, such as anxiety and irritability, along with cognitive decline [7] and delirium [8]. *Clinical nutrition in surgery* published by The European Society for Clinical Nutrition and Metabolism (ESPEN) in 2021 recommended that following cardiac surgery, patients should start drinking, eating, and obtaining nutrients early if they have regained consciousness and do not experience nausea, vomiting, or dysphagia after extubation [9]. However, most cardiac surgeons still follow the traditional recommendation of fasting for 4–6 h post-extubation. Current guidelines do not clearly indicate an appropriate post-extubation time for early oral hydration (EOH), and the information on its safety and effectiveness remains insufficient. A prospective study evaluated patients from different intensive care units (ICUs), who differed in age and endotracheal intubation time, for swallowing ~ 90 mL of water at 1, 4, and 24 h post-extubation [10]. Remarkably, at 1 h post-extubation, 82.2% of patients had no dysphagia.

Water is the gentlest mechanical stimulant of the gastrointestinal tract in our diet [11]. Early intake of small amounts of warm water after extubation is beneficial because it can promote vagus nerve excitation, activate the gastrointestinal neuroendocrine axis, stimulate gastrointestinal peristalsis, and shorten the gastrointestinal exhaust time without significantly increasing gastrointestinal adverse reactions [12].

In this randomized controlled trial, the cardiac surgery patients were assigned either to the EOH group or the conventional oral hydration (COH) group for evaluating the safety and effectiveness of water intervention at 1 h post-extubation. The study hypothesized that EOH could relieve thirst, stabilize the oral environment, and improve patient satisfaction without affecting the incidence of postoperative nausea or vomiting, and aspiration pneumonia.

Methods

Design and participants

In this prospective, single-center, randomized, controlled trial, cardiac surgery patients were screened at the Fujian University Affiliated Union Hospital from October 2021 to February 2022. The inclusion criteria were as follows: patients undergoing elective cardiac surgery; aged ≥ 18 years; no dysphagia during preoperative screening; capability to communicate and understand instructions; and no pneumonia before surgery. The following patients were excluded: history of neurological diseases (dementia, cerebral infarction, etc.); open injuries in the oral cavity before surgery (such as mandible injury), and history of cancer.

In this study, the method of continuous sampling was adopted. The researcher screened the patients before surgery, invited the patients who met the inclusion criteria to participate, and informed them of the purpose, method, and significance of this study. Once the patients agreed to participate, they immediately signed the informed consent form.

All voluntary participants could withdraw from the study at any time. The study design followed the CONSORT guidelines and was approved by the Ethics Committee of the Union Hospital affiliated with Fujian Medical University (2021KY105).

Randomization and allocation concealment

The patients were divided into EOH and COH groups using the block randomization method. In order to ensure the random distribution of subjects, a nurse, who did not participate in any other work related to the study, generated random numbers using IBM windows SPSS statistics version 23.0. The 84 subjects were divided into 14 block groups; the 6 subjects in each block group were numbered, and then randomly divided into either the EOH group, with numbers of 1–3, or the COH group with numbers of 4–6. The nurse put them into sequentially coded, sealed, and opaque envelopes. Once informed consent was sought and provided, the envelopes were opened in sequence, and the subjects were randomly assigned to one of the two groups in a 1:1 ratio. The researchers and subjects could not predict the distribution sequence. All data of patients were input and analyzed by a nurse with a master's degree. Because the patients signed informed consent forms and the researchers were two trained nurses, the EOH and COH groupings were obvious and could not be blinded. However, the two nurses responsible for data collection and the nurse in charge of data input and analysis were blinded.

Intervention

Both groups received oral care (brushing and gargling) immediately post-extubation. First, the thirst intensity of patients in the EOH group was evaluated using a numerical rating scale (NRS) [13], a straight 10-cm line, equally divided into ten parts. The NRS increases successively from 0 on the left, which represents no thirst, to 10 on the right, which represents intense thirst. Patients were requested to answer the following questions: “If 0 represents no thirst and 10 represents intense thirst, what do you consider as the most severe thirst, how would you rate your current thirst?” Second, patients were assessed for safety using the Safety Protocol for Thirst Management (SPTM) [14], which was authorized by Professor Fonseca and included three evaluation indicators: (1) level of awareness: asking the patient’s name; (2) airway protection: placing hands on the chest or abdomen to make the patient cough and swallow, and (3) nausea and vomiting: asking the patient about whether they felt nauseous. If one of the indicators failed, patients did not receive thirst management. Finally, patients who passed the SPTM at 1 h post-extubation were asked to perform a water-drinking test. In the test, the patient was in a 45° semi-decubitus position and allowed to drink 30 mL of warm water. The following observations indicated dysphagia: patients could swallow once but with choking; patients could swallow twice or more but with choking or frequent choking; or patients could not swallow. Patients with dysphagia had to retain the nil per OS (NPO) status. Without signs of dysphagia, the reported risk of aspiration is minimal when the

gastric volume does not exceed 50 mL [15]. Therefore, 50 mL of warm boiled water was administered hourly over a period of 4 h, vaseline was then applied to the lips every hour after the intervention. If the patient experienced gastrointestinal adverse events, including nausea and vomiting, at any time during the intervention, the patient's status was changed to NPO. Patients evaluated by SPTM could receive or reject the intervention at any time.

The patients in the COH group retained the NPO status for 4 h post-extubation. During that time, the researchers applied cotton swabs with water to the patients' lips every hour, followed by vaseline. Then, the patient was placed in a 45° semi-recumbent position for a 30-mL water-swallow test. If dysphagia, nausea, or vomiting occurred post-extubation, the patient's status was changed to NPO, and the responsible nurse had to contact the attending physician for further instructions. Without adverse events, the patient was instructed to drink the water slowly. The SPTM assessment was required before all interventions.

Before leaving the ICU, the patients used the 5-point Likert scale [16] to score satisfaction with the thirst management intervention: 1, clearly dissatisfied; 2, somewhat dissatisfied; 3, neutral; 4, satisfied; 5, very satisfied. The Likert scale is widely used to evaluate postoperative satisfaction in various fields, including thirst and fluid management. Moreover, this simple assessment tool does not significantly increase the nursing workload in high-intensity ICUs.

In this study, basic patient information and perioperative clinical characteristics were extracted from electronic medical records. The blood gas index was the latest blood gas analysis report before extubation. During the 4 h post-extubation period, data on gastrointestinal adverse reactions, aspiration pneumonia, thirst intensity, unstimulated saliva flow rates (USFR), saliva pH, oropharyngeal comfort (halitosis and oral mucosal moisture level), and patient satisfaction were collected by two nurses who had worked for > 5 years and were uniformly trained before data collection.

Outcomes

Primary outcome

The primary outcome was the thirst intensity, which was assessed using the NRS before the hourly intervention as follows: 0, not thirsty; 1–3, mild thirst; 4–6, moderate thirst; and 7–10, severe thirst. In the EOH group, the thirst intensity was evaluated before the intervention every hour; the COH group maintained the NPO status 4 h after extubation, and the thirst intensity was evaluated every hour.

Secondary outcomes

The secondary outcomes were adverse gastrointestinal reactions, aspiration pneumonia, USFR, salivary pH, oral odor, oral mucosal moisture, and patients' satisfaction. Gastrointestinal adverse reactions mainly included nausea and vomiting. Nausea is a subjective, unobservable, unpleasant sensation in the back of the throat and upper abdomen that may or may not cause vomiting and is known as "feeling sick in the stomach." Vomiting is the oral expulsion of gastrointestinal contents [17]. Nausea and vomiting

symptoms of the patients after the intervention were evaluated using the WHO classification standard [18] as follows: 0, no nausea or vomiting; I, mild symptoms, nausea only, no vomiting; II, moderate symptoms, transient vomiting with nausea; III, moderate symptoms, vomiting requiring treatment, and IV, severe symptoms, uncontrollable vomiting. After the intake of water by the patients, the incidence of adverse gastrointestinal reactions was recorded in both groups. If the result of evaluation is greater than 0, the intervention cannot be continued.

Aspiration pneumonia refers to the inflammation of pulmonary parenchymal lesions caused by inhalation of oropharyngeal secretions, food or gastric contents, and other irritants. In addition to considering the risk factors for aspiration (dysphagia, impaired consciousness, impaired cough reflex, nasal feeding, and vomiting) and meeting the diagnostic criteria for pneumonia, the diagnosis of aspiration pneumonia was performed. Chest X-ray film or lung CT scan often shows new infiltration shadows in the posterior segment of the upper lobe or the dorsal segment of the lower lobe and the posterior basal segment, and the right lung is more commonly affected than the left lung. Symptoms can be mild or severe, depending on the amount and nature of inhaled substances. Using chest auscultation, wet rales, burst sounds, or bronchial breathing sounds can be heard. Chest X-ray films can be negative, but infiltration shadows often appear 24–72 h after aspiration; leukopenia (white blood cell count < $4.0 \cdot 10^9$/L) or leukocytosis (white blood cell count > $10.0 \cdot 10^9$/L) can repeatedly occur [19]. Pneumonia data were collected within 72 h post-intervention.

The USFR is the volume of saliva obtained per minute (unit: mL/min) without exogenous or drug-induced stimulation; the amount of non-stimulated saliva is measured by spitting the saliva [20]. Within 4 h post-intervention, the patients were instructed to take a semi-reclining position to accumulate saliva, avoid saliva swallowing, and spit saliva in a weighed test tube (including cotton swab) once per minute. The residual saliva in the mouth was wiped with a cotton swab for 5 min, and then the total weight of the saliva was calculated. The saliva density is approximately equal to the density of water. Thus, the USFR was calculated using 1 g/mL. A USFR < 0.1 mL/min indicated insufficient salivary secretion [21]. The saliva pH was tested using precision pH test paper (pH 4.5–9.0, Taizhou Oak Filter Paper Co., Ltd., China). Oral odor was assessed using a halitosis detector (Shenzhen Micro Technology Co., Ltd., China). Patients were instructed to start blowing when the mouth was approximately 5 cm away from the blowing hole. Halitosis is divided into five levels, using scores of 0, 1, 2, 3, and 4; the higher the score, the heavier the halitosis. The state of the lips and mouth was assessed using the oral mucosal moisture score scale: 1, moist lips, moist mouth; 2, dry lips, moist mouth; 3, dry lips, dry mouth; 4, chapped lips, dry mouth [22]. All outcome indexes were evaluated at 1 h post-extubation, immediately before the intervention, and at 4 h post-intervention. Before leaving the ICU, the patients used the 5-point Likert scale [16] to score their satisfaction.

Sample size calculation

In this study, thirst intensity was taken as the primary outcome. Based on the change in the mean ± standard deviation of thirst intensity from 7.4 ± 3.4 pre-intervention to 5.1 ± 3.2 post-intervention [5], the sample size was calculated using the formula that compares the mean of two independent samples. It

was concluded that 42 people were needed in each group to provide a two-sided alpha of 0.05 and a one-sided power of 0.9.

Data analysis

Excel was used for data collection and management. Statistical analysis was performed using SPSS 23.0. Continuous variables (age, height, weight, body mass index, arterial blood gas index, thirst intensity, salivary pH, unstimulated saliva flow rate, objective oral mucosa scale, bad breath score, patient satisfaction) with normal distribution are expressed as mean ± standard deviation; whereas those with skewed distribution (endotracheal tube size, intubation duration) are expressed as median and quartile (range). Categorical variables (sex, history of smoking, family history of heart disease, history of diabetes, New York Heart Association class, type of surgery, surgery mode, perioperative and postoperative medications, gastrointestinal adverse reactions, aspiration pneumonia) were expressed as frequency using the chi-square test or Fisher's exact test. In addition to ANOVA for repeated measurement for thirst intensity, independent sample T test was used for other normally distributed data. Mann–Whitney *U* test was applied to non-normally distributed data. Results with $P < 0.05$ were considered statistically significant.

Results

In all, 84 patients were enrolled and randomly divided into the EOH group (n = 42) and COH group (n = 42). In the EOH group, except for one patient with asthma, 41 patients passed the SPTM assessment and underwent the intervention as planned, but 2 patients developed dysphagia during the intervention. In the COH group, 42 patients underwent a thirst intensity assessment and passed SPTM after 4 h, but 1 developed dysphagia. (Fig. 1)

Intergroup differences in patient demographic and clinical characteristics

There were no significant differences between the 84 patients in the EOH and COH groups in terms of smoking history, family history of heart disease, diabetes history, cardiac function classification, surgery type, surgery mode, perioperative anesthetic and postoperative analgesic use, arterial blood gas index (K^+, Na^+, Ca^{2+}, Cl^-), osmotic pressure, intubation type, intubation time, and dysphagia after the water-drinking test (Table 1).

Table 1
Basic patient characteristics and clinical data

Variable	EOH group (n = 42)	COH group (n = 42)	*P**
Age, mean, y	52.55 ± 16.55	50.90 ± 15.01	0.87
Sex			0.37
Male (%)	23 (54.76)	27 (64.29)	
Female (%)	19 (45.24)	15 (35.71)	
Height, m	1.63 ± 0.10	1.64 ± 0.09	0.81
Weight, kg	58.33 ± 9.56	61.15 ± 12.55	0.63
Body mass index	21.78 ± 2.94	22.49 ± 3.55	0.30
History of smoking, No. (%)	9 (21.42)	6 (14.29)	0.39
Family history of heart disease, No. (%)	2 (4.76)	4 (9.52)	0.39
History of diabetes, No.(%)	3 (7.14)	3 (7.14)	0.99
NYHA class, No. (%)			0.24
≤II	5 (11.90)	9 (21.43)	
>II	37 (88.10)	33 (78.57)	
Type of surgery, No. (%)			
CABG	3 (7.14)	2 (4.76)	0.65
CABG and valve	2 (4.76)	3 (7.14)	0.35
Valve replacement			
Mitral	9 (21.43)	11 (26.19)	0.61
Aortic	4 (9.52)	3 (7.14)	0.69
Mitral and aortic	2 (4.76)	2 (4.76)	.099
Valve repair			

Abbreviations: EOH = Early oral hydration; COH = Conventional oral hydration; NYHA = New York Heart Association; CABG = Coronary artery bypass graft; Glu = Glucose; K^+=serum potassium; Na^+= serum sodium; Ca^{2+}= serum calcium; OSM = osmotic pressure; Cl^-=serum chlorine

Continuous variables are given in mean ± standard deviation or median [interquartile range, IQR 25th–75th percentiles] according to their distribution.

Values are given as mean ± standard deviation or median [interquartile range, 25th–75th percentiles]

Variable	EOH group (n = 42)	COH group (n = 42)	*P**
Mitral	7 (16.67)	8 (19.04)	0.78
Tricuspid	3 (7.14)	2 (4.76)	0.65
Mitral and tricuspid	3 (7.14)	2 (4.76)	0.65
Ascending aortic aneurysm repair	2 (4.76)	3 (7.14)	0.65
Heart transplantation	1 (2.38)	0 (0.00)	0.99
Surgery of congenital heart disease	4 (9.52)	2 (4.76)	0.67
Other surgery	2 (4.76)	4 (9.52)	0.67
Perioperative medications, No. (%)			
Sevoflurane	39 (92.86)	37 (88.10)	0.46
Propofol	11 (26.20)	10 (23.81)	0.80
Midazolam	32 (76.20)	34 (80.95)	0.60
Sufentanil	35 (88.33)	33 (78.57)	0.58
Rocuronium Bromide	40 (95.24)	37 (88.10)	0.24
Dexmedetomidine	40 (95.24)	41 (97.62)	0.56
Other medications	30 (71.42)	26 (61.90)	0.36
Postoperative medications, No. (%)			
Sufentanil	42 (100)	42 (100)	NA
Butorphanol tartrate	34 (80.95)	31 (73.81)	0.43
Tropisetron	39 (92.86)	42 (100)	0.07
Dexmedetomide	42 (100)	41 (98.21)	0.31
Dezocine	9 (21.43)	10 (23.81)	0.79
Other medications	2 (4.76)	6 (14.29)	0.27

Abbreviations: EOH = Early oral hydration; COH = Conventional oral hydration; NYHA = New York Heart Association; CABG = Coronary artery bypass graft; Glu = Glucose; K^+=serum potassium; Na^+= serum sodium; Ca^{2+}= serum calcium; OSM = osmotic pressure; Cl^-=serum chlorine

Continuous variables are given in mean ± standard deviation or median [interquartile range, IQR 25th–75th percentiles] according to their distribution.

Values are given as mean ± standard deviation or median [interquartile range, 25th–75th percentiles]

Variable	EOH group (n = 42)	COH group (n = 42)	*P**
Arterial blood gas index			
Glu, ummol/L	10.24 ± 3.47	10.21 ± 3.84	0.97
K^+, mmol/L	4.16 ± 0.35	4.14 ± 0.43	0.81
Na^+, mmol/L	161.49 ± 153.34	137.42 ± 5.23	0.31
Ca^{2+}, mmol/L	1.55 ± 0.56	1.68 ± 0.64	0.31
Cl-, mmol/L	100.82 ± 4.85	99.19 ± 4.62	0.12
OSM, mOSM/L	296.10 ± 10.79	294.68 ± 8.28	0.50
Endotracheal tube size, Median¶	7.5 [7.5,7.5]	7.5 [7.5, 7.5]	0.40
Intubation duration¶, Median, h	17.25 [14.0, 22.5]	17.75 [11.87, 42.12]	0.75
Dysphagia§, No. (%)	2 (4.77)	1 (2.38)	0.55
Abbreviations: EOH = Early oral hydration; COH = Conventional oral hydration; NYHA = New York Heart Association; CABG = Coronary artery bypass graft; Glu = Glucose; K^+=serum potassium; Na^+= serum sodium; Ca^{2+}= serum calcium; OSM = osmotic pressure; Cl^-=serum chlorine			
Continuous variables are given in mean ± standard deviation or median [interquartile range, IQR 25th–75th percentiles] according to their distribution.			
Values are given as mean ± standard deviation or median [interquartile range, 25th–75th percentiles]			

Primary outcome analysis

In this study, the analysis of variance of repeated measurement showed that there was a statistical difference in thirst intensity between the two groups ($F = 306.21$, $P < 0.001$). There was also a statistical difference in thirst intensity between the two groups at different time points ($F = 31.24$, $P < 0.001$); the mean of the thirst score decreased to 3.38 ± 1.04 in the EOH group after intervention, which was substantially lower than 8.24 ± 0.62 in the COH group. Furthermore, there was a statistical difference in the change trend of thirst intensity between the two groups ($F = 88.71$, $P < 0.001$). The NRS score decreased over time in the EOH group, but not in the COH group. (Table 2, Fig. 2)

Table 2
Comparison of thirst intensity between two groups at different time points (mean ± SD)

	No. (%) of patients	
Time	**EOH group (n = 42)**	**COH group (n = 42)**
1 h post-extubation	7.21 ± 1.13	7.32 ± 1.06
2 h post-extubation	5.72 ± 0.94	7.27 ± 0.90
3 h post-extubation	5.00 ± 0.827	7.59 ± 1.18
4 h post-extubation	3.38 ± 1.04	8.24 ± 0.62
Note:		
1. There was a significant difference in thirst intensity between the two groups (F = 306.210, P < 0.001)		
2. There was a significant difference in thirst intensity at different time points (F = 31.240, P < 0.001)		
3. The change trend of thirst intensity between the two groups was statistically different (F = 88.706, P < 0.001)		
Abbreviations: EOH, early oral hydration; COH, conventional oral hydration; SD, standard deviation.		

Secondary outcomes analysis

Post-extubation, 92.30% (36/39) of patients in the EOH group and 95.12% (39/41) of the patients in the COH group did not have nausea and vomiting. The two groups did not significantly vary ($P = 0.60$) (Table 2). There was no aspiration pneumonia in either group. The USFR and salivary pH of the two groups were not measured before the water-swallow test. After the intervention, the EOH group had a significantly higher USFR than the COH group (a mean of 0.18 in the EOH group vs. a mean of 0 in the COH group [95%CI 0.16 to 0.21], $P < 0.001$), and the salivary pH tended toward the normal range (a mean of 6.44 in the EOH group vs. a mean of 0 in the COH group [95%CI 6.110 to 6.77], P < 0.001). The between-group difference was significant. Before the intervention, both groups had similar halitosis (a mean of 3.38 in the EOH group vs. a mean of 3.41 in the COH group [95%CI -0.33 to 0.27], P = 0.84) and oral mucosal moisture scores (a mean of 3.28 in the EOH group vs. a mean of 3.34 in the COH group [95%CI -0.29 to 0.17], P = 0.61), but after the intervention, these two scores decreased significantly in the EOH group but not in the COH group (a mean of 2.77 in EOH group vs. a mean of 3.76 in the COH group [95%CI -1.23 to -0.75], P < 0.001) (a mean of 2.03 in the EOH group vs. a mean of 3.90 in the COH group [95%CI -2.13 to -1.63], P < 0.001). The satisfaction of patients in the EOH group was significantly higher than that of patients in the COH group (a mean of 4.28 in the EOH group vs. a mean of 3.15 in the COH group [95%CI 1.01 to 1.29], P < 0.001) (Table 3).

Table 3
Between-group differences in outcomes (N = 80)

	No. (%) of patients		
Dependent variable	**EOH group (n = 39)**	**COH group (n = 41)**	P*
Gastrointestinal adverse reactions (No. %)			0.60
No nausea and vomiting	36 (92.30)	39 (95.12)	
Nausea or vomiting	3 (7.70)	2 (4.88)	
Aspiration pneumonia, No. (%)	0 (0)	0 (0)	NA
Salivary pH			< 0.001
1 h post-extubation	0	0	
4 h post-extubation	6.44 ± 1.06	0	
Bad breath score			
1 h post-extubation	3.38 ± 0.75	3.41 ± 0.59	0.84
4 h post-extubation	2.77 ± 0.63	3.76 ± 0.43	< 0.001
USFR, mean			
1 h post-extubation	0	0	NA
4 h post-extubation	0.18 ± 0.08	0	< 0.001
Objective oral mucosa scale			
1 h post-extubation	3.28 ± 0.56	3.34 ± 0.48	0.61
4 h post-extubation	2.03 ± 0.74	3.90 ± 0.3	< 0.001
Satisfaction	4.28 ± 0.45	3.15 ± 0.48	< 0.001
Abbreviations: EOH = early oral hydration; COH = conventional oral hydration; USFR = unstimulated saliva flow rate.			
Values are given as mean ± standard deviation.			

Discussion

During the perioperative period, thirst is a common discomfort and a source of pain, with an incidence of 75–98% [23]. Sensing thirst can help reduce stress among nurses and emotional distress among patients. The study found that all patients were thirsty and in serious conditions. EOH significantly alleviated thirst, increased static saliva flow rate, restored saliva pH to the normal range, and reduced oral

malodor. The incidence of nausea or vomiting and aspiration pneumonia did not vary between the EOH and COH groups. Patients' satisfaction was also good. ICU patients have a high incidence of thirst because they are often in a state of strict fluid restriction and typically breathe with their mouth open. Patients commonly experience reduced saliva flow post-extubation. Before the intervention, the USFR of the participants was almost 0, and the saliva pH value could not be measured, which was consistent with the studies of the intubated and extubated patients who secreted almost no saliva during ICU admission [24–25]. Insufficient saliva secretion may be associated with a lack of oral intake and drugs, and the effects of potential diseases; placing the patients in the supine position could also prevent the uniform distribution of saliva in the oral cavity [26]. This study implemented an hourly intervention method and observed a time-dependent increase of saliva secretion in the EOH group but not in the COH group. In the EOH group, the thirst score was lower than that in the COH group. Moreover, in the EOH group, the salivary pH trended toward the neutral range; halitosis was alleviated; the lips, tongue, and oral mucosa were moist, and the patients were physiologically and emotionally satisfied compared with those in the COH group. Saliva contains various electrolytes, including sodium, potassium, calcium, magnesium, bicarbonate, and phosphate, along with immunoglobulins, mucins, and other proteins and nitrogen-containing molecules. These saliva constituents are involved in regulating saliva pH, promoting plaque metabolism, regulating tooth demineralization and remineralization, and exerting antibacterial activities to remove oral microorganisms [6]. In this study, it was further observed that patients in the COH group had dry mouth, insufficient saliva secretion, change in saliva pH, and aggravation of halitosis, along with dry lips, tongue, and buccal mucosa due to long-term prohibition of drinking and fasting, which corroborated previous results [27]. Furthermore, saliva secretion, saliva pH change, and the oral microorganism titer affect halitosis. Specifically, swallowing, chewing exercises, and drinking small volumes of water can directly wet the oral cavity and promote saliva secretion by the oral glands. Moreover, a previous study reported that thirst management by regular administration was better than on-demand administration [28].

Here, no between-group difference was detected in the incidence of gastrointestinal adverse events, which corroborated the results of another study [5]. Improvements in anesthesia technology, anesthetic drugs, and surgery have diminished the effects of anesthesia and surgery on the gastrointestinal tract [29–30]. In the present study, the routine use of antiemetic drugs (tropisetron) also reduced postoperative gastrointestinal complications. Studies have shown that the swallowing mechanism when drinking water can activate the neuroendocrine system, promote cellular secretion in the gastrointestinal tract, and accelerate hormone production. Moreover, elevated hormone levels can accelerate postoperative recovery in the intestine by promoting gastroenteric peristalsis and enhancing the emptying ability. Early postoperative oral feeding can also improve immunity and maintain the intestinal barrier function, which diminishes the incidence of postoperative gastrointestinal adverse reactions [31–32].

In this study, the incidence of aspiration pneumonia was 0, but in a study of patients after cardio-thoracic surgery, the reported incidence was 9.8% [33]. This could be related to the stricter evaluation before the intervention and the lower incidence of swallowing disorders in this study. Studies have confirmed that the intake of ≤50 mL reduces the risk of aspiration and ensures time-dependent absorption of the gastric

contents. The gastric half-emptying time is approximately 10–20 min, and 95% will be evacuated within 1 h after intake [15, 34]. Therefore, the ingestion of small volumes of liquid should be considered for thirst management strategies. Moreover, the incidence of dysphagia in this study after extubation was lower than the incidence of 5.6–67.5% observed in the study by Skoretz et al. [35] and that of 52% in the study by Plowman et al. [36]. The risk factors for dysphagia include New York Heart Association (NYHA) classes III and IV, endotracheal intubation model ≥ 8.0, intubation time > 27 h, and age ≥ 65 years. The probability of dysphagia increases twice for every 12 h of endotracheal intubation time or 10 years of age, and it can be ignored in patients with < 12 h intubation time. In this study, the mean age in the two patient groups was 50 years, the typical intubation time was approximately 17 h, and the intubation model was 7.0 or 7.5. Most of the above-described study subjects were not at risk of dysphagia, which may be the reason for the low incidence observed in the study. Furthermore, oral lubrication (i.e., endogenous saliva produced by drinking water lubricated teeth, tongue-palate, and tongue-mucosal interfaces) plays a critical role in swallowing, chewing, and tactile perception [25].

A limitation of this study was the single ICU approach, which restricted popularization and representativeness. Moreover, the oral microorganism profile was not evaluated before and after the intervention; this should be considered as an observation parameter in future studies. Finally, gastric ultrasound was not used to monitor gastric contents before oral hydration. This can be added in future studies to improve the safety of the intervention. The advantage of this study is its prospective design. The study strictly evaluated the EOH group according to the SPTM protocol before intervention and used the water-swallow test to screen for dysphagia. It provides new evidence that EOH at 1 h post-extubation is safe and effective in cardiac surgery patients.

Conclusion

In conclusion, it was found that oral hydration at 1 h post-extubation was safe and effective. EOH reduced the symptoms of thirst and stabilized the oral environment. The incidence of gastrointestinal adverse reactions and aspiration pneumonia did not significantly differ between the EOH and COH groups. The study's results should be further confirmed by using more samples and involving multiple centers to convincingly advocate for the implementation of EOH in clinical practice.

Abbreviations

CABG=Coronary artery bypass graft; Ca^{2+}= serum calcium; Cl^{-}=serum chlorine; COH=Conventional oral hydration; EOH=Early oral hydration; Glu=Glucose; K^{+}=serum potassium; Na^{+}= serum sodium; NYHA=New York Heart Association; OSM=osmotic pressure; USFR=unstimulated saliva flow rate; Vs.=Versus; SD, standard deviation.

Declarations

Ethics approval and consent to participate

The study was approved by the Ethics Committee of the Union Hospital affiliated with the Fujian Medical University (2021KY105). Written informed consent was obtained from all patients or next of kin before inclusion. According to Chinese law, this post-hoc analysis did not require further ethics approval. The procedures used in this study adhere to the tenets of the Declaration of Helsinki.

Consent for publication

The study did not obtain consent to publish individual data and were unable to obtain or retrospectively seek consent from individual patients or their legal guardians for the publication of their data. All data were anonymous prior to publication.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions statement

LT designed the study and wrote the manuscript. LS provided substantial contributions to the conception of the study. PY performed data entry, statistical analysis. CQ performed data collection. CL and LY contributed to revising the manuscript critically for important intellectual content. All authors give their agreement to be accountable for all aspects of the work, and ensure the accuracy and integrity of any part of the work. All authors read and approved the final version of the manuscript.

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Figures

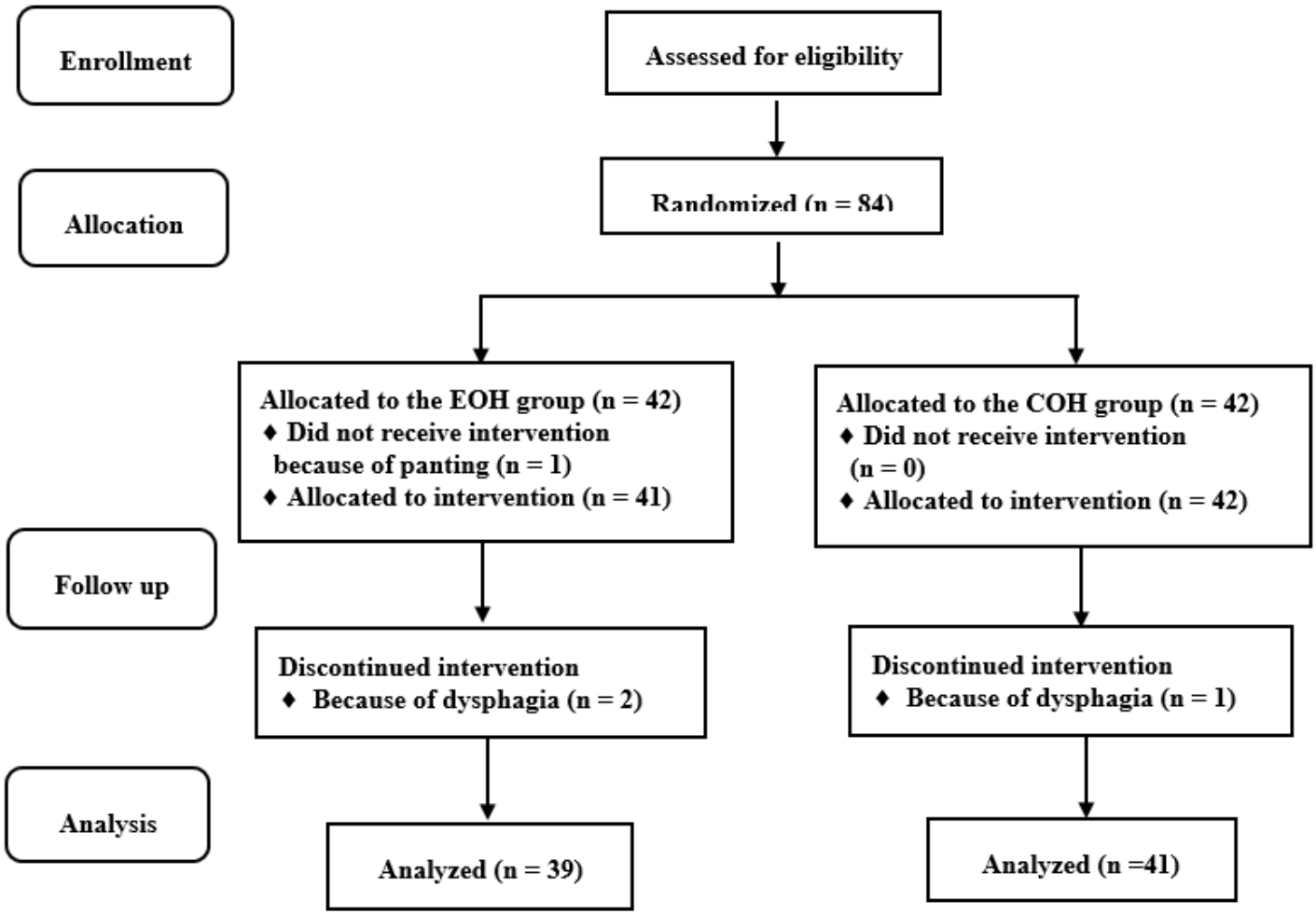

Figure 1

Flowchart of the study.

Abbreviations: EOH, early oral hydration; COH, conventional oral hydration.

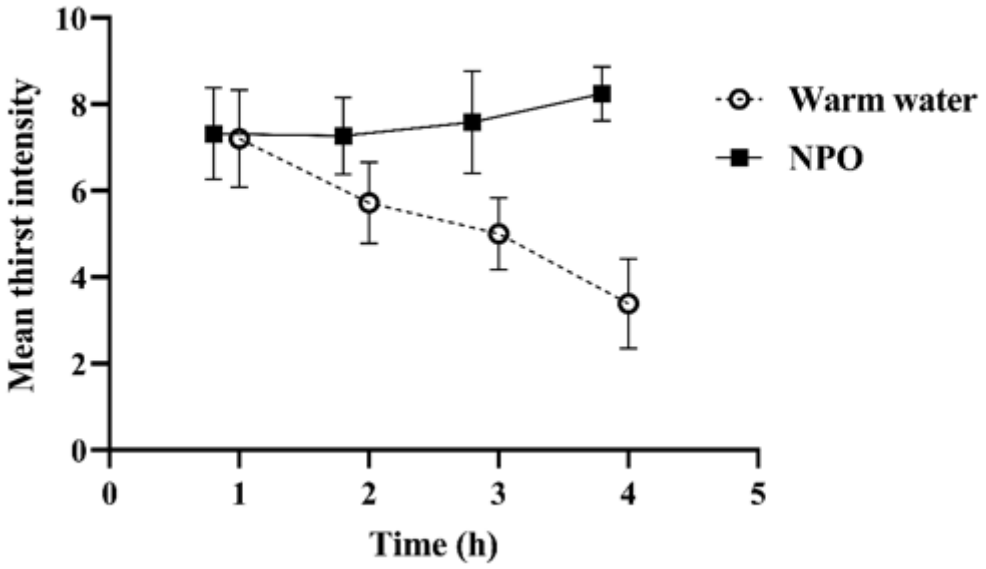

Figure 2

The change trend of thirst intensity at each time point in the two groups

Thirst intensity assessed at four different time points after extubation (i.e., every 1 h) in the EOH group (n = 39) and the COH group (n = 41).

Abbreviations: EOH, early oral hydration; COH, conventional oral hydration.