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RESEARCH ARTICLE

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Characteristics of oral mucosal pressure injuries in children with orotracheal intubation in intensive care units: An observational study

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Abstract

Background: Tracheal intubation can be used for ventilation to ensure an unobstructed respiratory tract, and it is the most common respiratory support technique used in paediatric intensive care unit (PICU) patients. Orotracheal intubation is usually the preferred method of tracheal intubation. However, it can cause stress-related damage to the oral mucosa. Identifying the factors that cause oral mucosal pressure injury (OMPI) can prevent its occurrence in children with oral endotracheal intubation.

Aim: To examine the characteristics of OMPI in children who underwent orotracheal intubation in the PICU and to assess their influencing factors.

Study Design: An observational, prospective study. Data were gathered from the PICU of a tertiary hospital in China between January 2023 and October 2023. The patient data were obtained from the 'General Information Questionnaire', 'Paediatric Critical Illness Score', 'STRONGkids Scale' and 'OMPI Staging and Assessment Tools'. Data analysis was subsequently performed using univariate and logistic regression analyses.

Results: A total of 187 children who underwent orotracheal intubation were analysed. During the observation period, 44.92% ($n = 84$) of the children developed OMPI. It comprised 63.10% ($n = 53$) of stage I injuries, 33.33% ($n = 28$) of stage II injuries and 3.57% ($n = 3$) of stage III injuries. The common injury sites were the lower jaw (48.81%), upper jaw (29.76%), tongue (20.24%) and joints (10.71%). The logistic regression analysis results revealed that high critical illness (OR = 0.835, 95% CI: 0.726–0.961), long intubation time (OR = 1.043, 95% CI: 1.021–1.067), prone ventilation (OR = 6.708, 95% CI: 1.421–31.670), hypothermia (OR = 5.831, 95% CI: 1.208–28.149), use of dental pads (OR = 5.520, 95% CI: 1.150–26.487) and low albumin levels (OR = 6.238, 95% CI: 1.285–30.281) were the main contributing factors for OMPI in children with orotracheal intubation (p < .05).

Conclusions: The occurrence of OMPI in children who underwent orotracheal intubation in the PICU was notable and was predominantly observed in stages I and II. Consequently, clinical nursing personnel should proactively recognize risk factors and administer timely interventions to mitigate the occurrence of OMPI in such children.

Relevance to Clinical Practice: The incidence of OMPI in children who underwent orotracheal intubation was relatively high. Nurses and doctors should closely monitor the risk factors for orotracheal intubation in children to prevent the occurrence of OMPI.

KEYWORDS

child, intensive care unit, intratracheal intubation, oral mucosa, pressure injury

1 | INTRODUCTION

With recent advancements in medicine, the prevalence of life support and therapeutic medical equipment usage in intensive care units (ICUs) has increased. Consequently, ICU patients face heightened susceptibility to medical device-related pressure injuries (MDRPIs) because of restricted mobility, sedation (resulting in an inability to report stress or discomfort) and medical equipment usage during treatment.[1] Previous research has indicated that the occurrence rate of MDRPI among ICU patients ranges from 34.5% to 48.8%.[2,3] Unlike conventional skin pressure injuries (PIs), MDRPI can manifest in mucosal tissues, particularly in the respiratory and gastrointestinal tracts.[3] In 2016, the European Pressure Injury Advisory Committee defined mucosal pressure injury (MPI) as a mucosal injury resulting from medical device use, typically categorized as a type of MDRPI.[4] Compared with non-ICU patients, ICU patients face an increased risk of MPI because of the diverse range of medical equipment utilized. Other studies report MPI incidence rates among adult ICU patients ranging from 33.3% to 63.7%.[1,3] Among these cases, tracheal intubation is the primary procedure leading to MPI, with the oral cavity being the most affected site.[5–7] Similarly, instrument-related PIs caused by endotracheal intubation pose significant risks in paediatric patients. Stellar et al.[8] conducted a study involving 625 children across eight paediatric hospitals in the United States, identifying tracheal intubation as the leading cause of MPI in children.

Tracheal intubation, an essential technique ensuring unobstructed respiratory passages, is the most prevalent method of respiratory support in PICU patients. It encompasses orotracheal and nasotracheal intubation. Orotracheal intubation is commonly favoured because of its ease, speed, especially in emergency situations, and reduced discomfort.[9] However, factors such as tube material, fixation methods and prolonged tube compression increase the risk of oral mucosal pressure injury (OMPI). PIs resulting from endotracheal tubes pose significant concerns in patient care, increasing the likelihood of pain, infection, prolonged hospital stays, heightened psychological distress and increased medical expenses.[10,11] In severe cases, it can lead to permanent disfigurement and functional impairments[12] while also augmenting nurses' clinical workload and potentially sparking medical disputes.

What is known about the topic

- Oral tracheal intubation is a commonly used method of respiratory support in ICUs, but the risk of OMPI increases because of the material, fixation method and continued compression of the line.
- Previous studies reported OMPI in a limited way, and studies of OMPI in the child have not been identified.

What this paper adds

- The main contributing factors for OMPI in children with orotracheal intubation include high risk of severe disease, prolonged intubation, prone ventilation, hypothermia, use of dental pads and low albumin levels.
- This study provides certain reference value for medical personnel to understand and prevent the occurrence of OMPI in children undergoing oral tracheal intubation.

The incidence of OMPI caused by tracheal intubation in adults in the ICU ranges from 31.3% to 55.6%.[10,13] The influencing factors are mainly divided into three categories: patient, medical device and iatrogenic factors. Patient factors include age, malnutrition, severe critical illness, prone position ventilation, the use of vasoactive drugs and steroids, and high blood sugar[4,8,13,14]; medical device parameters include the use of dental pads, fixation methods (including tying or fixing with adhesive tape and string) and medical device duration[13]; and iatrogenic factors include nonstandard oral care and nurses' insufficient understanding of the OMPI.[15] Owing to growth and development milestones, the physiological condition of children's skin is also unique. The soft nature of children's muscles and adipose tissue makes them more susceptible to deformation damage than adults.[16] Additionally, owing to children's immature cognitive states and motility characteristics, they can easily resist medical equipment. Additional protection and immobilization are often required to keep them safe.[8] Paediatric patients are more likely to develop OMPI.

The incidence of OMPI varies significantly based on patient age (adults or children) and the type and shape of the instrument used. Moreover, few studies have explored children's OMPI, leading to an unclear understanding of their characteristics and influencing factors. Therefore, this study focused on assessing the incidence and influencing factors of OMPI in paediatric patients who underwent orotracheal intubation in the ICU.

2 | AIM OF RESEARCH

The aim of this study was to investigate the causes of OMPI in children who underwent orotracheal intubation in the PICU and to analyse the factors influencing OMPI.

3 | DESIGN AND METHODS

3.1 | Study design

This study is a cross-sectional descriptive study designed to investigate the occurrence of OMPI in children who underwent orotracheal intubation in the PICU. We analysed the relevant influencing factors of the OMPI.

The endotracheal intubation fixation method in this study was performed in accordance with local PICU procedures, and the tracheal tubes used in the study were secured with tape.[17] In the PICU, the routine care of a child with an orotracheal tube is as follows. The child's facial position was safeguarded by a water colloid dressing. During routine endotracheal tube supervision, the position of the endotracheal tube was repositioned every 6 h. During prone ventilation, the endotracheal tube position changed every 4 h, and we increased the frequency of head position changes (every 2 h).[18] If secretions excessively contaminate the tape, the catheter position is changed more frequently.

3.2 | Sample and setting

Our hospital, a specialized children's hospital, treats approximately 1000 children annually and performs mechanical ventilation (including invasive and non-invasive ventilation) on approximately 500 children. It serves various cities within the province and neighbouring regions. Multiple specialized ICUs have been established, with the PICU serving as the primary treatment unit for critically ill patients within the internal medicine system. The PICU comprises 25 beds and employs 53 nurses.

This study focused on children who underwent orotracheal intubation in the PICU. The inclusion criteria were as follows: (1) aged 29 days to 14 years; (2) intubation through an orotracheal tube for ≥24 h; and (3) provided by informed consent to the child's parents. The exclusion criteria were as follows: (1) patients who underwent two or more tracheal intubations during the observation period; (2) patients who already experienced oral mucosal damage before tracheal intubation; (3) patients whose oral cavity underwent surgical surgery and was in a recovery period; and (4) patients who underwent a surgical procedure or surgery.

This is a cross-sectional study and requires an estimate of the population mean sample size.[19] According to our sample size calculation method, the sample size should be at least 5–10 times that of the independent variable. Through a literature review[20] and clinical practice, it is preliminarily estimated that there are 15 meaningful independent variables. Therefore, the sample size was approximately 150 cases ($10 \times 15 = 150$), and the sample size increased by 15% to a minimum value of 173. Hence, 187 children were included in the study.

3.3 | Data collection

The data of the subjects included in this prospective study were collected between January 2023 and October 2023. The data were collected by using general data (demographic data and disease-related data), the paediatric Critical Illness Score (PCIS), STRONGkids Scale, and the OMPI Staging and Evaluation Tools.

The general data, the paediatric critical case score scale and the STRONGkids scale, were collected by the main investigator, whereas the OMPI stages were collected by bedside nurses (bedside nurses had 24 h of experience and could effectively observe and collect the children's oral mucosa) and the nursing professor. Before data collection, relevant experts conduct unified training, and data collection can be carried out only after qualification. This ensures consistent data collection.

3.4 | Research tools

The general data, including demographic data and disease-related data, were included after consulting the relevant literature and clinical practice details. The demographic data included sex, age, height and weight (extracted from electronic medical records). The disease-related data (extracted from electronic medical records and collected by bedside nurses) included disease type, blood sugar level, albumin level during tracheal intubation, consciousness state, use of vasoactive drugs and corticosteroids, duration of mechanical ventilation and use of medical devices.

PCIS.[21] The PCIS is a widely used and effective paediatric critical assessment system in China that is utilized for evaluating the severity of children's illnesses. It comprises 11 indicators, including heart rate, blood pressure, respiration, arterial oxygen partial pressure, pH, sodium ions, potassium ions, serum creatinine, blood urea nitrogen, haemoglobin and gastrointestinal manifestations. Arterial oxygen partial pressure measurements were conducted without oxygen inhalation. This scoring is completed within 24 h of admission. Each indicator is assigned points ranging from 4 to 10, with a total possible score of 100 points. Scores between 71 and 80 are categorized as critical, whereas values of ≤70 are considered extremely critical. Furthermore, disease grades are determined on the basis of children's physiological values and recent test results after scoring. Studies have shown that the PCIS can indicate the severity of the disease,[21,22] and the Hosmer–Lemeshow test revealed that the PCIS can predict mortality and actual mortality with the best fit ($\chi^2 = 7.573$, $p = .476$).

Nutritional Risk Screening Tool. The STRONGkids scale is employed for nutritional risk screening.[23] And it encompasses four aspects: (1) subjective comprehensive evaluation, assessing subcutaneous fat, muscle loss, etc., with a score of 1 point; (2) malnutrition-related high-risk diseases, with a score of 2 points; (3) dietary situation, with a score of 1 point; and (4) loss of body mass and growth difficulties, with a score of 1 point. On the basis of scoring standards, values of 0, 1–3 and ≥4 are classified as low-, medium- and high-risk cases, respectively. Studies have shown that, compared with other screening tools, STRONGkids has high clinical value in the nutritional screening of critically ill children.[24] The area under the receiver operating characteristic curve of the STRONGkids was 0.822, and the sensitivity for screening for malnutrition was 92.1%.

OMPI Staging and Evaluation Tool. Developed by the research team, this tool is based on ROMPIS,[25] pressure ulcer classification, clinical practice and expert consultation. It categorizes evaluation scores into three stages: stage I involves redness and swelling, localized redness of the oral mucosa, clear boundaries, no obvious destruction or epithelial tissue loss and the absence of ulcers or blisters. Stage II indicates damage to oral mucosa integrity, with the appearance of blisters, blood or mucosal tissue clots without underlying fascia injury. Stage III involves exposure and damage to mucosal and submucosal tissues, with the involvement of the oral fascia and lower muscles. We prepared 19 OMPI photographs of orotracheal intubation in children for assessment. The interrater reliability of the total scale between the two observers was 0.632, indicating moderate agreement on the basis of the criteria of Choi.[13] Content validity verification of the tool was conducted using a four-point Likert scale by two dentists; all items scored >80% validity.

3.5 | Statistical analysis

The statistical analysis was performed using IBM SPSS 26.0 software (IBM, Armonk, NY, USA).

The counting data are presented as frequencies and composition ratios. Normally distributed data are presented as mean ± standard deviations, and non-normally distributed data are presented as the median (P_{25}, P_{75}). *Univariate analysis* was used to assess the difference in the characteristics of OMPI and no OMPI in children with orotracheal intubation. The chi-squared test was used for comparisons of count data between the groups. For quantitative data, if the data were normally distributed, homogeneous variance was assessed using two independent samples *t*-tests; if the data were not normally distributed, the Mann–Whitney *U* test was used for intergroup comparisons. Logistic stepwise regression analysis was used to evaluate the influencing factors of OMPI in children who underwent orotracheal intubation in the ICU. All the results were assessed at a confidence interval of 95% and a significance level of $p < .05$.

3.6 | Ethics considerations

This research was approved by the Ethics Review Committee of our hospital before the start of the study (batch number: 2023-k-099, approval date: 9 January 2023). Written consent obtained from the child's parents was collected before the study data.

4 | RESULTS

4.1 | Demographic data and hospital-related characteristics of children undergoing orotracheal intubation in the PICU

A total of 187 children who underwent orotracheal intubation in the ICU were selected, including 99 boys (52.9%) and 88 girls (47.1%). Table 1 shows the age distribution of the participants, with 19.00 (7.00, 49.0) months and a BMI of 16.36 (15.33, 17.54). The types of disease included respiratory disorders ($n = 59$ [31.6%]), haematologic disorders ($n = 49$ [26.2%]), neurological disorders ($n = 43$ [23.0%]), endocrine system disorders ($n = 27$ [14.4%]) and other disease types ($n = 9$ [4.8%]) (Table 1).

4.2 | Characteristics of OMPI in children with orotracheal intubation in the ICU

During the observation period, 84 children exhibited OMPI, resulting in an incidence rate of 44.92% ($n = 84$). It comprised 63.10% ($n = 53$) of stage I injuries, 33.33% ($n = 28$) of stage II injuries and 3.57% ($n = 3$) of stage III injuries. The most prevalent sites were the lower jaw (48.81%), upper jaw (29.76%), tongue (20.24%) and joints (10.71%). *Univariate analysis* indicated that the PCIS score, tracheal intubation duration, nutritional risk screening score, blood glucose level, albumin level, disturbance of consciousness, use of vasoactive and steroid drugs, usage of dental pads, mild hypothermia treatment and prone position ventilation significantly influenced PI occurrence following tracheal intubation (Table 2).

TABLE 1 Demographic data and hospital-related characteristics of children who underwent orotracheal intubation in the PICU.

Independent variable	*n* (%)/M(P_{25}, P_{75}) ($N = 187$)
Age (months)	19.00 (7.00, 49.0)
BMI	16.36 (15.33, 17.54)
Gender	
Male	99 (52.9%)
Female	88 (47.1%)
Disease type	
Respiratory disorders	59 (31.6%)
Haematologic disorders	49 (26.2%)
Neurological disorders	43 (23.0%)
Endocrine system disorders	27 (14.4%)
Other	9 (4.8%)
Blood glucose level	
Normal (3.9–6.1 mmol/L)	40 (21.4%)
Abnormal (<3.9 mmol, >6.1 mmol/L)	147 (78.6%)
Albumin level	
Normal (3.6–5.2 g/dL)	85 (45.5%)
Abnormal (<3.6 g/dL, >5.2 g/dL)	102 (54.5)
Whether to use mild hypothermia treatment (32–35°C)	
Yes	31 (16.6%)
No	156 (83.4%)
Whether to merge consciousness disorders	
Yes (drowsiness, blurring, lethargy, coma)	129 (69.0%)
No (wakefulness)	58 (31.0%)
Whether to use vasoactive drugs	
Yes	102 (45.5%)
No	85 (54.5%)
Whether to use corticosteroids	
Yes	38 (20.3%)
No	149 (79.7%)
Whether to ventilate in a prone position	
Yes	75 (20.3%)
No	149 (79.7%)
Whether to use dental pads	
Yes	89 (47.6%)
No	98 (52.4%)

[Correction added on 10 October 2024, after first online publication: The entries under the 'Disease type' column in Table 1 have been corrected in this version.]

4.3 | OMPI-associated patient- and hospital-related characteristics evaluated by multiple logistic regression analysis

The statistically significant factors in the above *univariate analysis* were assigned and analysed using logistic regression analysis.

The model's prediction accuracy was 94.1%. The regression model fit the real data well, and the Hosmer–Lemeshow goodness-of-fit test yielded $\chi^2 = 4.735$, $p = .786$. The results revealed that high critical illness (OR = 0.835, 95% CI: 0.726–0.961), long intubation time (OR = 1.043, 95% CI: 1.021–1.067), prone ventilation (OR = 6.708, 95% CI: 1.421–31.670), hypothermia (OR = 5.831, 95% CI: 1.208–28.149), use of dental pads (OR = 5.520, 95% CI: 1.150–26.487) and low albumin levels (OR = 6.238, 95% CI: 1.285–30.281) were the main influencing factors of OMPI in children who underwent tracheal intubation in the ICU (Table 3).

5 | DISCUSSION

Our findings indicate that the incidence of OMPI in children who underwent orotracheal intubation was 44.92%, exceeding the incidence reported in adults (31.3%).[10] Owing to variations in childhood growth and development, children's mucous membranes are more susceptible to damage, with the lower jaw being the most vulnerable site (48.81%), which is attributed to the positioning of the endotracheal tube and the use of dental pads. Placing the dental pad centrally in the oral cavity increases the shear force between medical instruments and the mucous membrane because of compression between the dental pad, endotracheal tube and incisors, leading to OMPI. Moreover, for every hour of endotracheal tube indwelling, the risk of OMPI increases, as prolonged contact between the mucosa and the tube leads to mucosal drying and increased friction and shear forces. Doctors and nurses should assess the necessity of invasive mechanical ventilation and tracheal intubation daily and discontinue or remove the tube as early as possible. The study revealed that the children with dental pads were at a 5.52-fold greater risk of OMPI than those without dental pads, which aligned with the findings by Choi et al.[13] Factors contributing to this include the lack of dental pads tailored for children of different ages by manufacturers and children's lower degree of cooperation, potentially rejecting medical equipment usage and resulting in restlessness. Additionally, the use of multiple adhesive tapes for fixation in clinical practice increases the risk of OMPI.

Prone position ventilation involves placing patients in a prone position during mechanical ventilation to increase lung recruitment and oxygenation, which are commonly utilized in the treatment of acute lung injury and acute respiratory distress syndrome patients.[26] However, its clinical application is associated with complications, with oral mucosal damage being a primary adverse effect. Our results revealed that the children undergoing prone position ventilation had a 6.283-fold greater risk of OMPI than those who were not prone on ventilation, which is consistent with the findings by Togluk and Aydoğan.[27] This may be attributed to prolonged face-down positioning causing mucous membrane oedema.[28] Furthermore, decreased oral mobility and difficulty in changing the endotracheal tube position during prone ventilation increase the need for catheter fixation to prevent unplanned extubation, thereby augmenting shear forces between the tube and oral mucosa and predisposing patients to OMPI. For children undergoing prone position ventilation, nurses should intensify

TABLE 2 Univariate analysis of general data on the development of OMPI in children with orotracheal intubation in the PICU.

Independent variable	OMPI occurred ($n = 84$) N (infection rate, %)/ median (P_{25}, P_{75})/mean ± standard deviation [95% CI]	No OMPI occurred ($n = 103$) N (infection rate, %)/median(P_{25}, P_{75}) [95% CI]	Statistical values (X^2/Z)	$N = 187$ p value
Gender			0.203[a]	.652
Male	46 (54.8%) [44.2%–65.4%]	53 (51.5%) [41.8%–61.2%]		
Female	38 (45.2%) [34.6%–55.8%]	50 (48.5%) [38.8%–58.2%]		
BMI	16.45 (15.43, 17.64) [16.34–16.56]	16.36 (15.18, 17.25) [16.08–16.64]	−0.674[b]	.501
Age stager			−1.485[b]	.137
Infant period (≤ 12 months)	26 (31.0%) [21.1%–40.9%]	46 (44.7%) [35.1%–54.3%]		
Early childhood (12 months–)	36 (42.9%) [32.3%–53.5%]	32 (31.1%) [22.2%–40.0%]		
Preschool age (37 months–)	8 (9.5%) [3.2%–15.8%]	11 (10.7%) [4.73%–16.67%]		
School-age and above (73 months–)	14 (16.7%) [8.7%–24.7%]	14 (13.6%) [6.98%–20.2%]		
Disease type			−1.250[b]	.211
Respiratory disorders	21 (25.0%) [15.7%–34.3%]	38 (36.9%) [27.6%–46.2%]		
Haematologic disorders	23 (53.1%) [42.4%–63.8%]	26 (25.2%) [16.8%–33.6%]		
Neurological disorders	25 (29.8%) [20.0%–39.6%]	18 (17.5%) [10.2%–24.8%]		
Endocrine system disorders	12 (14.3%) [6.8%–21.8%]	15 (14.6%) [7.78%–21.42%]		
Other	3 (3.6%) [0%–7.6%]	6 (5.8%) [1.3%–10.3%]		
Critical care score	71.54 ± 6.79 [70.06–73.01]	82.0 (78.0, 84.0) [78.0–84.0]	−9.270[b]	<.001
Duration of tracheal intubation (h)	178.5 (144.0, 257.75) [121.63–235.38]	88.0 (69.0,103.0) [86.87–89.13]	−9.661[b]	<.001
Nutrition risk score	5.0 (4.0, 5.0) [4.0–5.0]	3.0 (3.0, 4.0) [3.0–4.0]	−8.509[b]	<.001
Blood glucose level			1.182[a]	.277
Normal (3.9–6.1 mmol/L)	21 (25.0%) [15.7%–34.3%]	19 (18.4%) [10.9%–25.9]		
Abnormal (<3.9 mmol, >6.1 mmol/L)	63 (75.0%) [65.7%–84.3%]	84 (81.6%) [74.1%–89.1%]		
Albumin level			53.694[a]	<.001
Normal (3.6–5.2 g/dL)	63 (75.0%) [65.7%–84.3%]	22 (21.4%) [13.5%–29.3%]		
Abnormal (<3.6 g/dL, >5.2 g/dL)	21 (25.0%) [15.7%–34.3%]	81 (78.6%) [70.7%–86.5%]		
Whether to merge consciousness disorders			38.006[a]	<.001
Yes (drowsiness, blurring, lethargy, coma)	77 (91.7%) [85.8%–97.6%]	51 (49.5%) [39.8%–59.2%]		
No (wakefulness)	7 (8.3%) [2.4%–14.2%]	52 (50.5%) [40.8%–60.2%]		

TABLE 2 (Continued)

Independent variable	OMPI occurred ($n = 84$) N (infection rate, %)/median (P_{25}, P_{75})/mean ± standard deviation [95% CI]	No OMPI occurred ($n = 103$) N (infection rate, %)/median(P_{25}, P_{75}) [95% CI]	Statistical values (X^2/Z)	$N = 187$ p value
Whether to use sublow temperature (32–35°C)			7.823[a]	.005
Yes	21 (25.0%) [15.7%–34.3%]	10 (9.7%) [4.0%–15.4%]		
No	63 (75.0%) [65.7%–84.3%]	93 (90.3%) [84.6%–96.0%]		
Whether to use vasoactive drugs			22.827[a]	<.001
Yes	62 (64.3%) [54.1%–74.5%]	40 (26.2%) [17.7%–34.7%]		
No	22 (35.7%) [24.5%–46.0%]	63 (73.8%) [65.3%–82.3%]		
Whether to use corticosteroids			4.695[a]	.03
Yes	23 (27.4%) [17.9%–36.9%]	15 (14.6%) [7.8%–21.4%]		
No	61 (72.6%) [63.1%–82.1%]	88 (85.4%) [78.6%–92.2%]		
Whether to ventilate in a prone position			82.662[a]	<.001
Yes	64 (76.2%) [67.1%–85.3%]	11 (10.7%) [4.7%–16.7%]		
No	20 (23.8%) [14.7%–32.9%]	92 (89.3%) [83.33%–95.27%]		
Whether to use dental pads			45.926[a]	<.001
Yes	63 (75.0%) [65.7%–84.3%]	26 (25.2%) [16.8%–33.6%]		
No	21 (25.0%) [15.7%–34.3%]	77 (74.8%) [66.4%–83.1%]		

[a]Chi-squared test.
[b]Mann–Whitney U test.
[Correction added on 10 October 2024, after first online publication: The entries under the 'Disease type' column in Table 2 have been corrected in this version.]

TABLE 3 Logistic regression analysis for factors influencing OMPI incidence in children with orotracheal intubation.

Variable	B	Std. error	Wald value	p	OR	95% CI
Constant	1.607	6.536	0.060	.806	4.988	—
Critical care score	−0.181	0.072	6.360	.012	0.835	0.726–0.961
Duration of tracheal intubation (h)	0.043	0.011	14.246	<.001	1.043	1.021–1.067
Using sublow temperatures	1.763	0.803	4.818	.028	5.831	1.208–28.149
Low-level albumin	1.831	0.806	5.158	.023	6.238	1.285–30.281
Perform prone position ventilation	1.903	0.792	5.777	.016	6.708	1.421–31.670
Using dental pads	1.708	0.800	4.559	.033	5.520	1.150–26.487
Nutrition risk scorer	0.821	0.653	1.581	.209	2.273	0.632–8.174
Presence of impaired consciousness	0.045	1.042	0.002	.966	1.046	0.136–8.058
Use vasoactive drugs	1.060	0.801	1.751	.186	2.888	0.600–13.890
Use corticosteroids	−1.728	1.082	2.551	.110	0.178	0.021–1.481

the assessment of the oral mucosa and adjust the frequency of head turning and the position of the endotracheal tubes as needed.

Logistic regression analysis also revealed that a high PCIS was a protective factor against OMPI after tracheal intubation; however, an inversely scored PCIS was negatively correlated with the degree of critical illness in children. Therefore, the greater the degree of critical illness in children after tracheal intubation, the greater the chance of OMPI. This is because, in a critical state, haemodynamics are disturbed, and the skin mucosa, subcutaneous tissue and muscles are in a state of hypoperfusion, which is a high-risk factor for stress injury.

This study revealed that critically ill children experience increased nutritional consumption because of the influence of their disease and treatment factors. This often leads to hypoproteinaemia, resulting in a decrease in subcutaneous fat and deterioration of mucosal elasticity. This is a significant factor in the increase in the incidence of OMPI and is consistent with the studies of Kim et al.[10] and Choi et al.[13] Moreover, other studies have shown that the serum ALB concentration is also a nutrition-related factor that can significantly affect wound height.[29] Doctors and nurses should enhance the nutritional assessment of critically ill children, replenish lost energy and ensure that the nutritional requirements of patients are met.

The incidence of OMPI in children treated with mild hypothermia was greater than that in children not treated with mild hypothermia and was consistent with the Chinese Expert Consensus on Hypothermia Brain Protection (2020 Edition)[30] and Farid et al.,[31] which suggested that persistent hypothermia can increase stress injuries in patients. However, this finding was not consistent with the 'positive effects of mild hypothermia on the prevention of PI'.[32] The reason might be related to temperature control, the physiological characteristics of children and other factors, such as mild hypothermia treatment, which causes local metabolic rate reduction, oxygen consumption reduction and capillary constriction, thus increasing the risk of OMPI. During the application of hypothermia, nurses should pay attention to strengthening the protection of local skin tissue, reducing cold stimulation to the skin and preventing the occurrence of shivering.

6 | LIMITATIONS AND FURTHER RESEARCH

This study has a few limitations that must be considered. This study was limited to one hospital in China. Differences in tracheal tube care may lead to differences in clinical outcomes. In addition, we have only explored the influence of patient- and medical device-related factors on the OMPI and did not evaluate the effects of other oral environment factors, such as saliva and microbes, on the OMPI. In future, we aim to carry out a multicentre study with a larger sample size to develop a risk prediction model for orotracheal intubation for OMPI and to provide a reference for medical staff to comprehensively understand and manage the OMPI of children with orotracheal intubation. In the next step, we can develop risk prediction tools according to the characteristics of mechanical ventilation for children and develop management strategies for oral care for children using mechanical ventilation.

7 | CONCLUSIONS

Our study investigated the occurrence of OMPI in children with orotracheal intubation and suggested that medical staff pay close attention to children with critical illness, long-term endotracheal intubation, the use of dental pads, vasoactive drugs, prone position ventilation and continuous mild hypothermia treatment to prevent the occurrence of OMPI in multiple dimensions. This study provides certain reference value for medical staff to understand the occurrence of OMPI in children with orotracheal intubation.

AUTHOR CONTRIBUTIONS

Yueyue Zhao: writing – original draft, data curation. Jie Guo (co-first author): writing – review and editing. Jie Ma: software, investigation. Yanjun Ge: methodology. Junna Wang: investigation. Conghui Li: collection and organization of receipts. Caixiao Shi: conceptualization.

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DATA AVAILABILITY STATEMENT

Research data are not shared.

ETHICS STATEMENT

This study was approved by the Ethics Committee of Children's Hospital Affiliated to Zhengzhou University (Ethical permit ref. no: 2023-k-099). The study information emphasized voluntary participation and confidentiality.

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