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Postoperative care in ICU versus non-ICU after head and neck free-flap surgery: a systematic review and meta-analysis

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ABSTRACT

Objective Admission to the intensive care unit (ICU) has long been considered as routine by most head and neck surgeons after microvascular free-flap transfer. This study aimed to answer the question 'Is there a difference in the flap survival and postoperative complications rates between admission to intensive care unit (ICU) versus Non-ICU following microvascular head and neck reconstructive surgery?'.

Design Systematic review, and meta-analysis.

Methods The PubMed, Embase, Scopus and Cochrane Library electronic databases were systematically searched (till April 2021) to identify the relevant studies. Studies that compared postoperative nursing of patients who underwent microvascular head and neck reconstructive surgery in ICU and non-ICU were included. The outcome variables were flap failure and length of hospital stay (LOS) and other complications. Weighted OR or mean differences with 95% CIs were calculated.

Results Eight studies involving a total of 2349 patients were included. No statistically significant differences were observed between ICU and non-ICU admitted patients regarding flap survival reported (fixed, risk ratio, 1.46; 95% CI 0.80 to 2.69, p=0.231, I^2=0%), reoperation, readmission, respiratory failure, delirium and mortality (p>0.05). A significant increase in the postoperative pneumonia (p=0.018) and sepsis (p=0.033) was observed in patients admitted to ICU compared with non-ICU setting.

Conclusion This meta-analysis showed that an immediate postoperative nursing in the ICU after head and neck microvascular reconstructive surgery did not reduce the incidence of flap failure or complications rate. Limiting the routine ICU admission to the carefully selected patients may result in a reduction in the incidence of postoperative pneumonia, sepsis, LOS and total hospital charge.

Strengths and limitations of this study

- This is the first systematic review and meta-analysis to evaluate the postoperative outcomes of nursing in intensive care unit (ICU) versus non-ICU after head and neck microvascular reconstructive surgery.
- We analysed data from both randomised trials and observational studies.
- For some outcomes, the numbers of included studies were few.
- The major limitation of this study was the high heterogeneity between the published studies.

INTRODUCTION

Recently, microsurgical procedures including free-flap reconstruction have gained a wide popularity becoming the standard of care for various surgical defects of the head and neck region.[1] Free-flap surgery with various available flaps having different characteristics covers a wide range of indications in reconstructive head and neck surgery with different perspectives and an overall success rate reported up to 95%.[2]

Being considered as a major surgery with long intraoperative time, the postoperative care of free-flap surgery is considered critical and requires great attention. In addition, the need to closely monitor the flap viability for any vascular compromise occurring mostly in the first 48–72 hours increases the need for an accurate and close monitoring in the immediate postoperative interval; therefore, this interval is critical and of utmost important for successful salvage of ischaemic flaps.[3] Nevertheless, still which postoperative protocol is the most suitable is an issue of controversy and there is no international consensus between surgeons regarding a common monitoring regimen.[4]

For years, admission to the intensive care unit (ICU) has long been considered as routine by most head and neck reconstructive surgeons following free-flap surgery with a mean of 2.4 days admission in the ICU.[5] It was reported that 88.9% of surgeons prefer sending their free-flap patients to ICU even though most patients does not meet the cardiopulmonary indications of ICU admission.[6 7] In historic literature, certain postoperative treatment regimens stated complete patient immobilisation during the immediate postoperative period in an effort to protect the vascular pedicle.[8] This has evolved to the most common accepted standard where patients are spontaneously breathing at the conclusion of surgery. However, admission to the ICU is not without drawbacks due to prolonged mechanical ventilation, late ambulation, overuse of sedation, in addition to the higher incidence of pneumonia.[8 9] Accordingly, a different era of postoperative care of free-flap patients has been evolved recently in practice entailing the postoperative care at ward level or non-ICU postoperative care, with almost no significant differences in morbidity, mortality or flap failure between the ICU and ward-level postoperative care, but with lengthy hospital stay in those patients admitted to ICU.[10 11]

Reviewing the literature, there is no clear consensus which postoperative free-flap management protocol is better; an ICU admission versus non-ICU care. Due to lack of the evidence regarding which postoperative free-flap nursing is associated with the highest flap survival and lower complications rates, therefore, the current systematic review and meta-analysis aimed to summarise the available evidence and to answer the question 'Is there a difference in the flap failure and postoperative complication rates between the patients who postoperatively admitted to intensive care unit (ICU) or Non-ICU after microvascular head and neck reconstructive surgery?'

METHODS

This systematic review and meta-analysis adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement for reporting systematic reviews[12] (online supplemental table S1). The protocol of the meta-analysis has been registered on the PROSPERO platform (CRD42020207772).

Focused question

Is there a difference in the flap survival and postoperative complications rates between admission to ICU versus non-ICU following microvascular head and neck reconstructive surgery?

The question for the current meta-analysis was adopted to follow PICOTS criteria:

P: Patients who underwent tumour resection and free-flap reconstruction.

I: Participants who received nursing in ICU or non-ICU department.

C: ICU versus non-ICU admission.

O: Flap survival rate reoperation, readmission, and respiratory complications, delirium, sepsis, length of hospital stays (LOSs) or hospital cost.

T: Nursing in ICU for ≥12 hours versus immediate nursing in non-ICU unit.

S: Randomised controlled trial (RCT) or observational studies.

Search strategies

From inception to April 2021, an electronic search without time or language restrictions was done in the following databases: PubMed, Embase, Scopus and the Cochrane library (online supplemental table S2). The following terms were used in the search strategy on PubMed:

(((((((head and neck neoplasms [MeSH Terms]) OR (microsurgical free flap [MeSH Terms])) AND (nursing, perioperative [MeSH Terms])) OR (specialized care unit)) AND (ward care)) OR (care, surgical intensive [MeSH Terms])) AND (postoperative complications [Title/Abstract])) OR (flap failure[Title/Abstract]).

A manual search of the following journals was also performed: *International Journal of surgery*, *Journal of Plastic and Reconstructive Surgery*, *Journal of Plastic, Esthetic and Reconstructive Surgery*, *Journal of Annals of Plastic Surgery*, *Journal of Intensive Care*, *Journal of Intensive Care Medicine*, *Journal of Intensive Care*, *Journal of Head and Neck*, *Laryngoscope*, *British Journal of Oral and Maxillofacial Surgery*, *International Journal of Oral and Maxillofacial Surgery*, *Journal of Craniofacial Surgery*, *Journal of Cranio-Maxillofacial Surgery*, *Journal of Microsurgery*, *Oral Surgery Oral Medicine Oral Pathology Oral Radiology and Endodontology*, *Journal of Head and Neck Surgery* and *JAMA Otolaryngology Head and Neck Surgery*. The reference list of the identified studies and the relevant reviews on the subject was also evaluated for possible additional studies. Moreover, online databases providing information about clinical trials in progress were checked (clinicaltrials.gov; www. centerwatch.com/clinical trials; www.clinicalconnection.com). Details search strategy and number of yielded studies at different stages of screening are presented in figure 1 and online supplemental table S2.

Inclusion and exclusion criteria

Eligibility criteria included human experimental or observational studies that compared the immediate postoperative admission of patients undergoing head and neck reconstructive surgery to ICU versus non-ICU and reported one of the following outcomes: flap failure, reoperation, readmission and respiratory complications, delirium, sepsis, LOSs or hospital cost. The exclusion criteria were other studies that reported one of the following: (1) studies not comparing the postoperative ICU versus no-ICU care. (2) Studies with <30 patients in each group. (3) Studies including an anticipated need for postoperative ICU care. (4) Studies including patients under the age of 18. (5) Review studies, meeting abstracts and/or non-English articles.

Data extraction process

Two researchers independently assessed the titles, abstracts and full texts of the relevant studies and any controversy was resolved by discussion to reach a consensus. The following data were collected for each

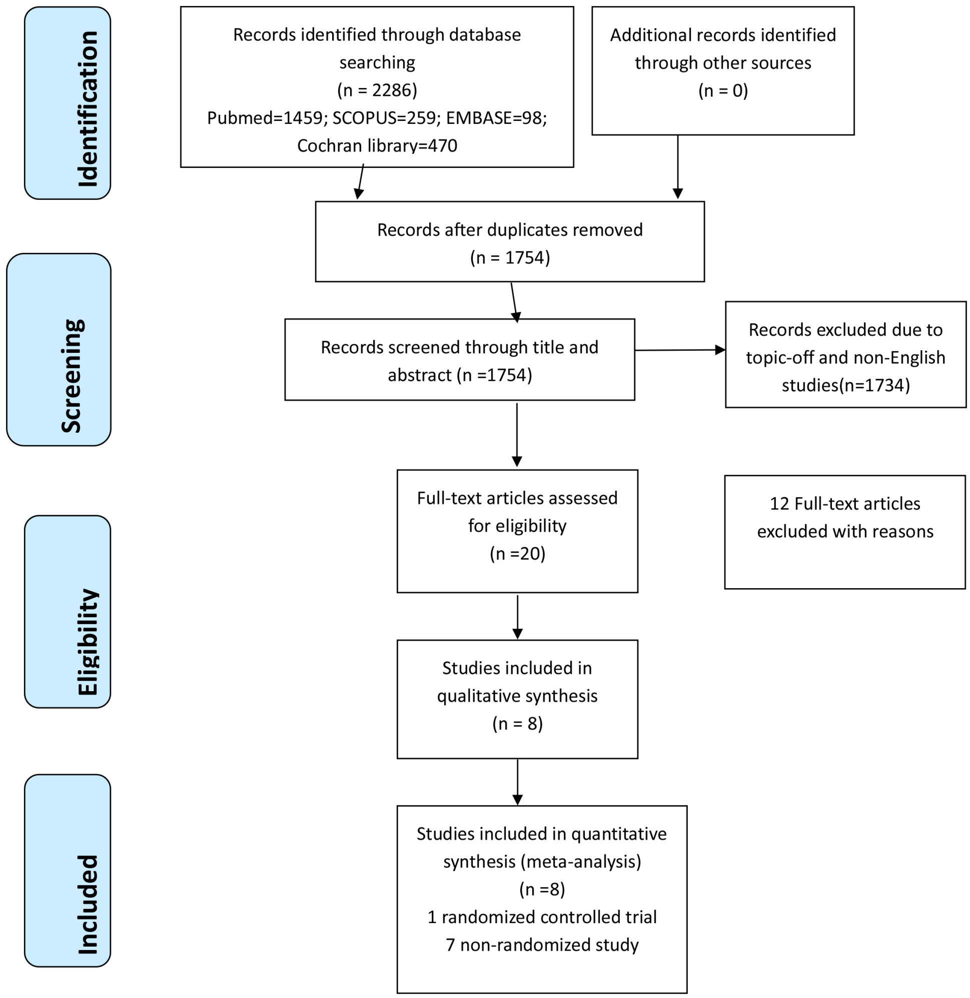

Figure 1 Study flow diagram.

study (when available): authors, publication year, country of origin, study design, age of the participants, number of patients in each group, length of ICU admission, LOS, nursing ratios during study, total hospital charge (THC), number of flap failure in each group and other outcomes (table 1). Two researchers independently reviewed the included articles and collected the data. Disagreements between the reviewers were resolved by discussion between and if necessary, a third reviewer was involved to reach a consensus. A further contact with authors for possible missing data was also performed.

Patient and public involvement

The present study was a meta-analysis and systematic review based on published data. Patients and public were not involved in the study design, conduct, data analysis and result dissemination.

Methodological quality appraisal

Two authors independently assessed the risk of bias in the included studies. Quality assessment of the risk of bias for RCTs was carried out using Cochrane collaboration's tool.[13] The RCTs were evaluated using the following six items: random sequence generation, allocation concealment, blinding of outcome assessment, incomplete outcome data, selected reporting and other bias. Study met all the above criteria; the study was then rated as low risk of bias. If one or more of the above domains were unclear, the study was considered as unclear risk of bias. If one or more of these criteria were not met, the study was classified as having a high risk of bias. The ROBINS-I tools[14] were used for assessment of the non-RCTs. The non-RCT studies were assessed using the following seven domains: confounding factors, selection of participants, measurement of interventions, departures from intended interventions, missing data, bias in measurement of outcomes and selection of reported results. The two independent authors then judged each study to be at low risk of bias, moderate risk of bias, serious risk of bias, critical risk of bias or no information (table 2).

Statistical analysis

For binary data, a risk ratio (RR) was estimated. For continuous data, the mean difference (MD) was estimated. The weighted RR or MD along with 95% CI was used to construct forest plots of the selected studies. The I^2 statistic was used to express the percentage of the total variation across studies due to heterogeneity; I^2 with 25% corresponding to low heterogeneity, 50% to

Table 1 Characteristics of the included studies

Study	Study design	Age (years)	No of participants	Length of ICU admission	Nursing ratios	LOS (days)	Flap loss	Total hospital charges (mean)	Outcomes
Nkenke *et al* 2009 Germany[18]	PS	Mean (SD) ICU=62.8 (9.7) Non-ICU=63.5 (9.5)	ICU=50 Non-ICU=50	Mean (SD) 3.5 (10.9)	NR	Mean ICU=10.28 Non-ICU=9.89	1	NR	Flap loss and other complications, readmission, length of hospital stays and hospital cost
Arshad *et al* 2013 USA[9]	RS	Mean ICU=59.2 Non-ICU=58.9	ICU=131 Non-ICU=126	NR	NR	Mean ICU=10.28 Non-ICU=9.89	9	ICU was US$2134 greater than non-ICU	Flap failure, LOS, hospital cost and other complications.
Yang *et al* 2019 USA[20]	RS	Mean (SD) 64.28 (11.70)	ICU=205 Non-ICU=100	NR	NR	Mean (range) ICU=6 (5–8). Non-ICU=5 (5–7)	9	35% higher hospital costs in ICU	Flap loss, reoperation, readmission, LOS, other complications.
Panwar *et al* 2015 USA[11]	RS	Mean (SD) ICU=62.46 (13.5) Non-ICU=63.3 (11.6)	ICU=175 Non-ICU=72	NR	1:3 to 1:4	Mean (range) ICU=8 (7–11) Non-ICU=7 (6–9.5)	9	Mean (range) ICU=US$33 642 (US$28 143–US$43 196; non-ICU= US$28 524 (US$22 611–US$33 226)	Flap failure, in-hospital mortality, and morbidity, hospital length of stay (LoS), total hospital-based charges, and cost of care, operative time, ischaemia time, site of tissue harvest.
Chen *et al* 2018 Taiwan[21]	RS	Mean (SD) ICU=53.8 ± 10.3 Non-ICU=52.2 ± 9.6	ICU=138 Non-ICU=179	NR	1:2 in the ICU; 1:9 during the day, 1:12 in the evening, and 1:16 in night shift in the ward	Mean (SD) ICU=22.1 ± 13.1 Non-ICU=24.2 ± 13.9	8	NR	Ventilation length, use of sedation, flap outcomes, flap complications, systemic complications, in-hospital mortality, and hospitalisation. Flap outcomes
Yalamanchi *et al* 2020 USA[22]	RS	Mean (SD) ICU=64.6 (13.0) Non-ICU=61.5 (13.2)	ICU=146 Non-ICU=192	Mean 7 (IQR 6–9) days	1:3	Mean (IQR) ICU=8.5 (6–9) Non-ICU=8 (4–8)	13	Mean ICU= US$47 315.44 Non-ICU= US$38 853.50	Postoperative complications, reoperation, and flap failure, ICU length of stay, total LOS, readmission rates, and hospital cost.
Cervenka *et al* 2019 USA[17]	RCT	>18	ICU=57 Non-ICU=61	ICU for 12–24 hour	1:3 and 1:4	Mean (range) ICU=8.89 (4–30). Non-ICU=8.97 (4–21).	1	Mean ICU= US$466 199 Non-ICU= US$486 150	LOS, flap failure rate, surgical and medical complications and total cost of hospitalisation
Clemens *et al* 2015 USA[19]	RS	Mean (SD) 60 (14.1) years	680 ICU=605 Non-ICU=75	NR	NR	Non-ICU=5.9 6 (1.8) ICU=9.56 (7.5)	10	NR	Flap failure rate, LOS, minor and major complications

ICU, intensive care unit; LOS, length of hospital stay; NR, not reported; PS, prospective study; RCT, randomised controlled trail; RS, retrospective study.

Table 2 Results of the quality assessment for non-randomised studies using ROBINS-I tools

	Preintervention	At intervention	Post intervention					
Study, year	Bias due to confounding	Bias in selection of participants into the study	Bias in classification of interventions	Bias due to deviations from intended interventions	Bias due to missing data	Bias in measurment of outcomes	Bias in selection of the reported result	Overall risk of bias
Nkenke *et al* 2009[18]	Moderate	Low	Moderate	Moderate	Moderate	Serious	Moderate	Serious
Arshad *et al* 2013[9]	Low	Low	Moderate	Moderate	Low	Moderate	Moderate	Moderate
Clemens *et al* 2015[19]	Low	Low	Moderate	Moderate	Low	Serious	Moderate	Serious
Panwar *et al* 2015[11]	Low	Low	Low	Low	Moderate	Moderate	Moderate	Moderate
Chen *et al* 2018[21]	Moderate	Low	Moderate	Low	Moderate	Moderate	Low	Moderate
Yang *et al* 2019[20]	Low	Low	Moderate	Moderate	Moderate	Moderate	Low	Moderate
Yalamanchi *et al* 2020[22]	Low	Low	Moderate	Low	Low	Moderate	Moderate	Moderate

moderate and 75% to high.[15] When I^2>50%, the random effect model was used as described by DerSimonian and Laird.[16] Otherwise, the data were regarded as homogeneous, and a fixed-effect model was used. A p value of <0.05 was considered statistically significant.[16] Subgroup mete-analysis or meta-regression will be conducted to explore possible causes of heterogeneity among study results. If there were sufficient included studies, a sensitivity analysis will be performed to assess the robustness of our meta-analysis. This can be achieved by exclusion of studies with a high risk of bias. If there will be enough studies, funnel plot will be conducted to investigate publication and other bias in meta-analysis. A Comprehensive Meta-Analysis Software V.3 (Biostat, Englewood, New Jersey) was used for data analysis.

RESULTS

The kappa value was 0.85, so the agreement between investigators was almost perfect. The electronic and manual searches identified 2286 articles (figure 1); 1754 records remained after removal of the duplicates. The titles and abstracts of the remaining 1754 articles were screened and 1734 records were excluded due to being off topic or non-English studies. The remaining 20 studies were carefully read by 2 researchers for potential inclusion. Of the 20 full-text studies reviewed for potential inclusion; 8 met the inclusion criteria and were assessed for reliability (table 1), with the other 12 articles excluded with reasons (online supplemental table S3). The 8 included articles had a total of 2349 participants. One study was a prospective RCTs[17] and the other studies were non-randomised studies.[9 11 18–22] Other general characteristics of the included studies are reported in table 1. The mean age of the patients ranged between 52 and 64 years. The nursing ratios were reported in four studies[9 11 17–22] (table 1).

Quality assessment

Based on the Cochrane collaboration's tool for risk of bias assessment, only one RCT[17] was included and was considered as having unclear risk of bias.

Based on the ROBINS-I tools for non-RCTs risk assessment, the overall risk of bias was moderate in five included studies,[9 11 17–22] whereas two studies[18 19] were rated as having serious risk of bias.

At the preintervention stage, confounding bias was low in most of the studies, except for two studies where confounding variables were moderate (table 2). The lack of randomisation is reflected in the moderate selection bias identified in the majority of the studies. For the postintervention stage, bias due to missing information was not clearly stated in all studies. Measurement of outcomes was serious in two studies because the method of outcome assessment was not reported completely (table 2).

Results of individual outcome variables

Flap survival

Flap survival was reported in 8 studies[9 11 17–22] with a total of 2349 patients. A total of 60 flaps were lost. The flap survival rate was 97.19% in the ICU group and 97.89% in the non-ICU admission; however, a statistically insignificant difference was reported (fixed, RR, 1.46; 95% CI 0.80 to 2.69, p=0.231, I^2=0%) (figure 2).

Reoperation and readmission to the ICU

Reoperation was reported in 5 studies[11 17 20–22] with a total of 1253 patients. The incidence of reoperation was 12.34% in ICU and 9.44% in non-ICU admissions; however, a statistically insignificant difference was reported (random, RR, 0.830; 95% CI 0.540 to 1.276, p=0.397, I^2=53%) (table 3). Readmission to ICU was reported in four studies[17 18 20 22] with a total of 861 patients. The incidence of readmission was 10.91% in ICU and 8.95% in non-ICU admissions; however, a statistically insignificant difference was reported (fixed, RR, 0.922; 95% CI 0.611 to 1.392, p=0.700, I^2=0%) (table 3).

Medical complications

The incidence of pneumonia was reported in four studies[17–20] (6.87% in ICU and 2.45% in non-ICU) with a total of 1203 patients. There was a statistically significant

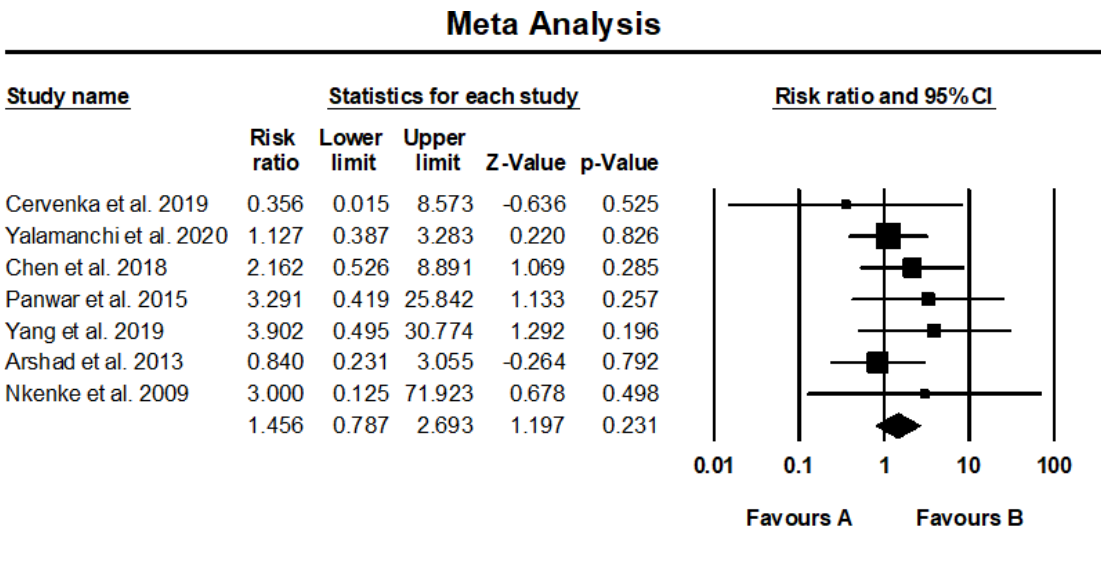

Figure 2 Forest plot of flap survival rate. There was no difference in flap failure between intensive care unit (ICU) and non-ICU admission (fixed, risk ratio, 1.49; 95% CI 0.80 to 2.69, p=0.182, I^2=0%). The horizontal lines indicate the 95% CI for the eight included studies. The squares in the middle of the lines indicate the mean effect of the study. The diamond shape at the bottom indicates the 95% CI for the pooled effect.

higher incidence of pneumonia in ICU compared with non-ICU nursing (fixed, RR, 2.769; 95% CI 1.193 to 6.424, p=0.018, I^2=0%) (figure 3).

The incidence of sepsis was reported in 5 studies[11 17–19 21] (1.6% in ICU and 0% in non-ICU) with a total of 1462 patients. There was a statistically significant higher

Table 3 Summary of the results of the individual outcomes

Outcome variable	No of study	No of patients	Incidence rate (%)	Effect size risk ratio (RR); (95% CI)	Heterogeneity test	P value
Flap survival	8	2349	ICU=97.19 in Non-ICU=97.89%	RR, 1.46; CI (0.80 to 2.69)	0%	0.231
Partial flap necrosis	2	880	ICU=1.98 Non-ICU=2.4	RR, 1.251; CI 0.321 to 4.876	0	0.747
Venous congestion	3	1097	ICU=2.90 Non-ICU=3.39	RR, 1.047; CI 0.486 to 2.257	0	0.906
Arterial thrombosis	3	1097	ICU=1.01 Non-ICU=1.97	RR, 0.804; CI 0.261 to 2.471	0	0.703
Reoperation	5	1253	ICU=12.34% Non-ICU=9.44%	RR, 1.327; CI 0.693 to 2.539	53%	0.394
Readmission	4	861	ICU=10.91% Non-ICU=8.95%	0.922; 95% CI 0.611 to 1.392	0	0.700
Pneumonia	4	1203	ICU=6.87 Non-ICU=2.45	RR, 2.769; CI 1.193 to 6.424	0	0.018
Respiratory failure	3	1027	ICU=11.33 Non-ICU=6.09	RR, 1.675; CI 0.911 to 3.078	35%	0.097
Need for ventilation	2	365	ICU=12.5 Non-ICU=10.52	RR, 1.926; CI 1.128 to 3.288	0	0.016
Sepsis	5	1462	ICU=1.6 Non-ICU=0	RR, 4.23; CI 1.12 to 15.91	0	0.033
Delirium	2	365	ICU=12.5 Non-ICU=6.02	RR, 2.067; CI 0.944 to 44.526	0	0.069
Mortality	3	1115	ICU=0.38 Non-ICU=0.32	RR, 0.633; CI 0.072 to 5.532	0	0.679

ICU, intensive care unit.

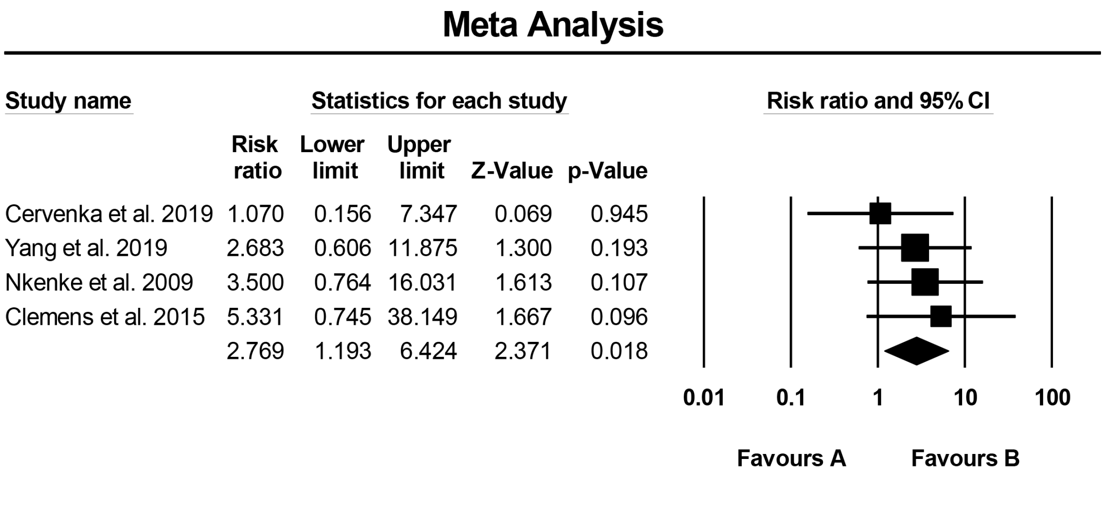

Figure 3 Forest plot of the incidence of pneumonia. There was statistically significant higher incidence of pneumonia in intensive care unit (ICU) compared with non-ICU nursing (fixed, risk ratio, 2.769; 95% CI 1.193 to 6.424, p=0.018, I^2=0%). The horizontal lines indicate the 95% CI for the four included studies. The squares in the middle of the lines indicate the mean effect of the study. The diamond shape at the bottom indicates the 95% CI for the pooled effect.

incidence of sepsis in the ICU compared with non-ICU (fixed, RR, 4.23; CI 1.12 to 15.91, p=0.033, I^2=0%) (figure 4).

No statistically significant difference was reported when comparing ICU and non-ICU concerning delirium, respiratory failure and mortality (p>0.05) (table 3).

LOS and THC

LOS was reported in 4 studies[17 19 21 22] with a total of 773 patients. The reported LOS stay ranged from 4 to 24 days (table 1). There was a statistically insignificant increase in LOS of about 1.5 day in the ICU group (random, MD, 1.5; 95% CI −0.835 to 3.861, p=0.270) (figure 5). We were unable to conduct meta-analysis regarding hospital charge due to heterogenety and missing of some data. Cervenka *et al*[17] reported no significant difference between ICU and non-ICU nursing regarding THC. Yang *et al*[20] stated that THC is about 35% higer in the patients admitted to ICU. Panwar *et al*[11] and Yalamanchi *et al*[22] reported a statistically significant difference between ICU and non-ICU caring p<0.001 and 0.00054, respectively.

DISCUSSION

The current systematic review and meta-analysis is novel in that it provides evidence to suggest that patients who will undergo head and neck microvascular reconstructive surgery may not require routine postoperative ICU care, and the non-ICU nursing can provide equivalent clinical outcomes. This was consistent with several reported studies;[9 11 18 23 24] however, this concept does not

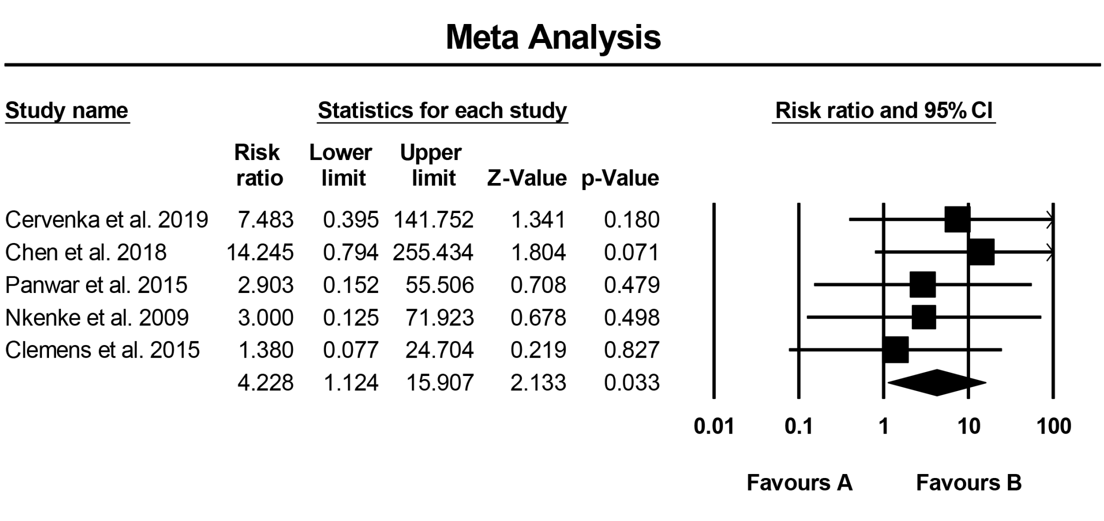

Figure 4 Forest plot of the incidence of sepsis. There was statistically significant higher incidence of sepsis in intensive care unit (ICU) compared with non-ICU nursing (fixed, RR, 4.23; CI 1.12 to 15.91, p=0.033, I^2=0%). The horizontal lines indicate the 95% CI for the five included studies. The squares in the middle of the lines indicate the mean effect of the study. The diamond shape at the bottom indicates the 95% CI for the pooled effect.

Meta Analysis

Study name	Difference in means	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Cervenka et al. 2019	-0.080	0.455	0.207	-0.972	0.812	-0.176	0.860
Yalamanchi et al. 2020	0.500	0.630	0.397	-0.735	1.735	0.793	0.428
Chen et al. 2018	2.100	1.524	2.323	-0.887	5.087	1.378	0.168
Clemens et al. 2015	3.600	0.220	0.049	3.168	4.032	16.337	0.000
	1.513	1.198	1.435	-0.835	3.861	1.263	0.207

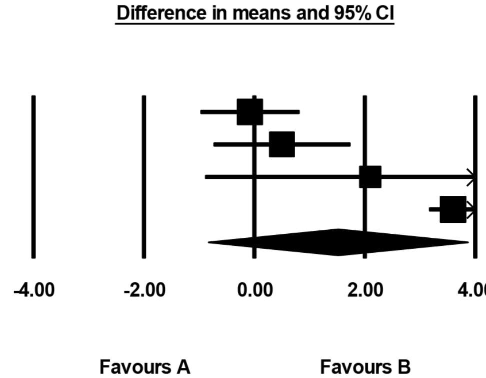

Figure 5 Forest plot of length of hospital stay (LOS). There was a statistically insignificant increase in LOS of about 1.5 day in the intensive care unit (ICU) group compared with non-ICU protocol. The horizontal lines indicate the 95% CI for the four included studies. The squares in the middle of the lines indicate the mean effect of the study. The diamond shape at the bottom indicates the 95% CI for the pooled effect.

mean that those patients do not require a special care, but, it is feasible if an appropriate environment and adequately trained nursing staff are available.[25] Bhama *et al* compared two types of ICU care (open vs closed) of patients with head and neck free-flap surgeries and they did not report any significant differences in the postoperative outcomes between the two nursing policies. The current meta-analysis included 8 studies with a total of 2349 patients and showed a statistically insignificant difference between ICU and non-ICU admission concerning flap survival rate. The pooled flap survival rate was 97.19% in the ICU group and 97.89% in the non-ICU group and this was consistent with the results obtained from other studies.[24 26] This result indicates that the postoperative admission in ICU or non-ICU settings does not influence flap survival rate. This was in line with the study performed by Chen *et al* in that they showed no significant difference in the flap survival rate between ICU and non-ICU caring and they reported flap success rate of 96.7% and 98.3%, respectively.

The common justification for routine postoperative care in the ICU of the patients who underwent microvascular free-flap reconstruction is close flap monitoring and airway management.[22] However, close flap monitoring can also be achieved in the non-ICU setting; provided that this is done by an adequately trained nursing staff and in a controlled environment, and this includes an hourly physical examination of the flap to assess colour, capillary refill, tissue temperature, turgor, pinprick test and Doppler signals. However, to improve the success rate of free flaps, particularly, in cases with poorly accessible flaps, an implantable Doppler would provide a higher flap salvage rate compared with the conventional monitoring method (81.4% vs 60.4%).[27]

On the other hand, to secure the airway after head and neck free-flap reconstruction and simultaneously decreasing the need for postoperative ICU care, Nkenke *et al*[18] considered primary tracheostomy as a key point that allows avoiding the need for ICU admission. In a postal survey performed by Marsh *et al*[7] in UK, they concluded that 69% of oral and maxillofacial surgeons prefer to perform tracheostomy after head and neck free-flap surgery. However, tracheostomy is still not without complications (amounted of about 8%–45%),[28 29] being chest infection the most common complication (8%).[25]

The reported incidence of readmission to ICU in the present study for previously nursed patients in ICU or non-ICU setting was 10.91% and 8.95%, respectively, and also no statistically significant difference was reported (p=0.7). These results indicated that patients underwent head and neck flap transfer might need readmission to ICU due to late postoperative complications, and these complications may happen regardless of the initial postoperative care in ICU or non-ICU setting.

Some surgeons belief that one of the benefits of the ICU admission is to limit patient mobilisation by using sedative medications and this would keep the vascular patency by preventing kinking of microvascular anastomoses and allows more invasive haemodynamic monitoring;[9] however, an evidence supporting or conflicting this belief is still lacking. In addition, admission to ICU is not free of disadvantages including nosocomial infections, cancellation of operation due to limited bed availability and increased cost.[10] Moreover, the use of sedation may decrease systemic blood pressure and subsequent reduction in blood perfusion of the flap.[4]

Postoperative pulmonary complications are one of the most frequent complications in patients undergoing radical head and neck cancer surgery with free-flap reconstruction, accounted for about 32% (pulmonary oedema in 23.6% and pneumonia in 9.1%).[30] Ibn Saied *et al*[31] conducted a large study on 14 212 patients who were admitted to the ICU for more than 48 hours. They reported the incidence of two types of pneumonia in patients admitted in the ICU; the ventilator-associated pneumonia 1161 (15%) and ICU–hospital-acquired pneumonia 176 (2%). The current meta-analysis showed a statistically significant higher incidence of postoperative pneumonia and sepsis in the ICU nursing group compared with non-ICU, p=0.018 and 0.033, respectively. The pooled incidences of pneumonia in ICU and non-ICU were 6.4% and 2.8%, respectively, meaning that patients admitted to ICU are at higher risk of development of ventilator-associated pneumonia or ICU–hospital-acquired pneumonia compared with non-ICU admitted patients.

We were unable to perform a meta-analysis concerning hospital charge because of the heterogeneity in the reported data. However, according to the existing literature, ICU care fee reported to be accounted for about 35% of the total hospital cost.[20] Therefore, admission to non-ICU care could reduce the high cost of ICU services and facilitates the management of available resources.

Although this systematic review and meta-analysis is the first to give a critical summary of the literature, pointing towards the unnecessity to nurse the carefully selected patients undergoing microvascular head and neck reconstructive surgery in the ICU setting. However, some limitations of this study should be declared. First, only one RCT was included; however, conducting a well-designed RCT in the field of reconstructive surgery appears to be difficult because there are many methodological and practical challenges of the surgical trials, such as recruitment, patient and surgeon preferences, feasibility of blinding, surgical quality control and standardisation of interventions. Second, several cofounders that might have an effect on the postoperative outcomes were not evaluated in the included studies such as the level and specialist training of the staff, nurse to patient's ratio, amount of intraoperative fluid used, use of vasopressors and anticoagulant and so on. For an optimum comparison of different nursing protocols with the least bias, homogeneous sample of patients with the same flap type and flap size, same recipient site, same perioperative care is needed. Third, although there was a consensus among the included studies in that ICU care increases the total hospital cost of care, no meta-analysis was performed due to both missing and heterogeneity in the reported data. Fourth, the non-English studies were excluded from the present study which may result in what is called language bias; however, several studies shown that exclusion of non-English publications from systematic reviews did not significantly affect the results of the meta-analyses.[32 33] In addition, studies published in non-English languages are difficult to locate, and may require translation, which will increase costs and delay the conclusion of a review.

Nevertheless, the current meta-analysis provides evidence regarding the feasibility of nursing the carefully selected patients undergoing head and neck free-flap surgery in non-ICU setting.

Conclusion

The present systematic review and meta-analysis demonstrate that an immediate postoperative ICU admission of patients who have undergone microvascular head and neck reconstructive surgery did not reduce flap failure and postoperative complication rates. However, limiting the routine ICU admission to the carefully selected patients may result in a significant cost savings and reduction in the incidence of postoperative pneumonia and sepsis. Regardless where was the nursing of the patients who underwent head and neck microvascular flap surgery, the availability of an appropriate environment and adequately trained nursing staff is the main key points and essential in the management of the postoperative complications.

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