Research Article

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Journal of Intensive and Critical Care
ISSN 2471-8505

2021

Vol. 7 No. 10 : 58

Predictors of Prolonged Intensive Care Unit Length of Stay among Surgical Patients: A Scoping Review

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Citation: Kaki A, Khalil AH, Nagshabandi E (2021) Predictors of Prolonged Intensive Care Unit Length of Stay among Surgical Patients: A Scoping Review. J Intensive Crit Care Vol.7 No.10: 58.

Abstract

Objective: This review aims to identify relevant studies related to predictors of prolonged intensive care unit length of stay among surgical patients in the literature.

Methods: The search strategy for this review identified published literature in the following databases: PubMed, MEDLINE, CINAHL, and other sources (Google scholar), using appropriate search terms. The search was limited to full-text journal articles published in the English language from 2015 to 2021 and articles that studied the predictors of prolonged Intensive Care Unit-Length of Stay (ICU-LOS) among surgical patients. It excluded articles that were not peer-reviewed, qualitative studies, unpublished articles, and conference papers.

Results: Overall, twenty-five studies met the inclusion criteria. Of the twenty-five studies, nineteen had a retrospective design, and three used an observational cohort design. Three studies had a prospective study design. However, two studies did not mention which design was used. Several themes were identified from the review, including preoperative factors associated with prolonged ICU-LOS among surgical patients, intraoperative and postoperative factors associated with prolonged ICU-LOS among surgical patients, the impact of intubation and use of mechanical ventilators on ICU-LOS, and outcomes of prolonged ICU-LOS.

Conclusion: Most of the reviewed studies involved the postoperative factors that contribute to increasing ICU-LOS, such as bleeding, intubation, sepsis and use of a mechanical ventilator. Few studies were found related to pre and intraoperative predictors. Thus, having nurses who can detect the predictors that may prolong ICU-LOS and provide appropriate management as early as possible is crucial.

Keywords: Adults; Intensive care unit; Length of stay; Perioperative periods

Received date: August 24, 2021; **Accepted date:** September 03, 2021; **Published date:** September 13, 2021

Introduction

Prolonged hospital stays in intensive care units exerts financial and economic problems to patients, health care providers, and the nation's economy [1]. Early recognizing and identifying patients who are at risk of having prolonged ICU-LOS was the main objective in many studies. Thus, management of some of the predictors that affect resource consumption can be an alternative to adding expensive resources [2].

The perioperative environment is a clinical area where nurses have a role to participate as members of the collaborative perioperative team in contributing to nursing assessment, implementation, and evaluation of the care provided [3]. Therefore, nurses need to have enough skills to identify and manage complications or comorbidities in the perioperative period.

A higher number of comorbidities can be predictors of surgical complexity. This includes an excessive requirement of blood transfusion that might be indicated secondary to bleeding, malnutrition, and shock or unstable vital signs. Another example, some of the physiological factors such as, hyperglycemic patients who are more susceptible to infection secondary to compromised immunity and altered healing capabilities. Similarly, patients suffering from Acute Kidney Injury (AKI), which is one of the common postoperative complications, because a slight elevation of serum keratinizes, may increase the patient's mortality [4]. The patient and surgical factors are important information for predicting ICU-LOS. However, the extent of how these factors can be utilized to manage patients' conditions and comorbidities is unclear [5].

Postoperative ICU-LOS has been studied within different aspects such as the utilization of resources, prognosis prediction, management in the perioperative period, and selection of patients. Various studies have proved that prolonged ICU-LOS is related to adverse short-term and long-term prognosis. It has been reported that advanced age, emergent surgery, previous cardiac surgery, recent myocardial infarction, use of inotropic drugs, preoperative renal failure, and peripheral artery disease are considered as predictors for prolonged ICU-LOS [6].

However, the ability of nurses to recognize and identify these predictors as early as possible will help in reducing the load on ICU and health care facilities by decreasing ICU-LOS. Thus, this review aims to identify relevant researches related to predictors of prolonged ICU-LOS in perioperative period among surgical patients in the relative literature findings.

Methods

Search strategy

This scoping review utilized Arksey et al., Framework [7], which was further developed by Levac et al. It starts with searching and identifying relevant studies, selecting the most relevant studies, chart the data, and then report the results [8].

Inclusion and exclusion criteria

The most relevant articles were selected by following the inclusion criteria, which are:

1 Articles published over five years from 2015 to 2021.

2. English language articles.

3. Articles that study the predictors of prolonged ICU-LOS among surgical patients.

Exclusion criteria involved

1. Not peer-reviewed articles.

2. Qualitative studies.

3. Not published articles.

4. Conference papers.

The search strategy helps the researcher to collect on current edge research material that fulfills the research subject [9]. The search strategy for this review identified any published literature in the following databases; PubMed, MEDLINE, CINAHL, and other sources (Google scholar), using appropriate search terms (keywords), which are listed in Table 1.

Table 1: Search terms and keywords.

Search terms
Predictors AND prolonged AND length of stay OR increased AND surgical ICU OR surgical intensive care unit AND surgical patients

The search was limited to full-text journal articles that were published in the English language in the period from 2015 until 2021. Thus, this review was built on the extend of knowledge in previous works.

Studies Selection Process

The Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) search guidelines were used in this review [10]. First, all identified studies (n=1885) from databases (CINAHL and Medline=59, PubMed=26, other sources=1800) were exported to EndNote reference management software then duplications were identified and removed, number of articles remained after the duplications removed were 80 articles. Next, the 1720 articles were checked by title, and 1664 articles were excluded because of the irrelevancy of the topic. After that, the remaining 56 articles were evaluated for eligibility criteria by reviewing titles and abstracts; a total of 31 articles were excluded, 14 out of 31 articles were excluded for irrelevant design, and 17 were excluded because of not peer-reviewed articles.

Finally, twenty-five full-text articles were identified in the second level screening to determine which articles to include in the review. Refer to Figure 1 for the PRISMA flow diagram of the selection process. The review identified the inclusion and exclusion criteria that would result in relevant documents to achieve the study objectives.

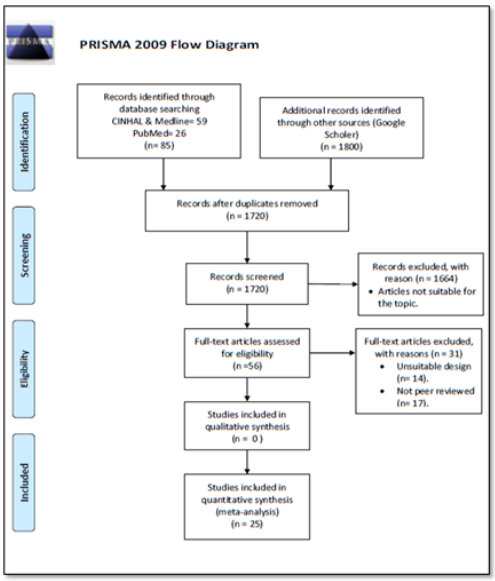

Figure 1: PRISMA flow diagram.

Appraisal of Quality

The quality appraisal for the 25 articles were evaluated, assessed, and appraised by using an assessment scale adapted from Berra et al., [11]. This assessment scale uses appraisal of ten aspects of the study regarding the research design and selection, definition and measurement of proposed variables, data collection method and analysis, and quality of results and discussion (Table 2).

The scoring system for the quality appraisal of the studies ranges from 1 to 10, in which scoring of 1 to 3 means low quality, scoring of 4 to 7 means moderate quality, and scoring eight and above is considered high quality. Table 3 points out the quality appraisal for all the studies.

Table 2: Study appraisal aspects.

Appraisal aspect	Items
Research design and selection	• Inclusion criteria for patients are indicated clearly. • Selection of sample is specified. • Research design is specified in the paper. • Information about comparisons of the group is mentioned.
Definition and measurement of proposed variables	• A clear definition of study variables is mentioned. • Use of validated instruments to study the proposed variables
Data collection method and analysis	• Appropriate sample size. • Specification about statistical tests.
Quality of results and discussion	• Clear reporting of results. • Practical implications of the findings and benefits for patients.

As showed in Table 3, in this review, the included studies' scores ranged from 6 to 9. Six studies scored as moderate quality (4 to 7) [12-17]. While the remaining nineteen studies were scored a high-quality score (8 to 10). There was no study found to be scored as low quality (1 to 3).

A data extraction form (Matrix) was used to extract study characteristics including authors' name, publication year, research method and design, research sample, the results, and study limitations (Table 4).

Table 3: Quality assessment of the included articles (n=25).

No	Articles	Items scoring										Total	Quality
		1	2	3	4	5	6	7	8	9	10		
1	Akavipat et al.	x	✓	✓	x	✓	x	✓	✓	✓	✓	7	Moderate
2	Al-Attar et al.(2019)	✓	✓	✓	✓	✓	x	✓	✓	✓	x	8	High
3	Barrie et al. (2019)	✓	✓	✓	✓	✓	✓	✓	✓	✓	x	9	High
4	Çevik et al. (2019)	✓	x	✓	✓	✓	✓	✓	✓	✓	✓	9	High
5	Chacon et al. (2019)	✓	x	x	✓	✓	✓	✓	✓	✓	✓	8	High
6	Diab M et al. (2017)	✓	x	✓	x	✓	✓	✓	x	✓	x	6	Moderate
7	Diab M et al. (2018)	✓	✓	✓	x	✓	✓	✓	✓	✓	x	8	High
8	Evans et al. (2018)	✓	✓	✓	✓	✓	x	✓	✓	✓	x	8	High
9	Higuchi et al. (2020)	✓	✓	✓	✓	✓	✓	✓	✓	✓	x	9	High
10	Hosokawa et al.	x	x	✓	✓	✓	✓	✓	✓	✓	x	7	Moderate
11	Johnston et al. (2017)	✓	✓	x	✓	✓	x	✓	✓	✓	✓	8	High
12	Kapadohos et al. (2017)	✓	✓	✓	x	✓	✓	x	✓	✓	✓	8	High
13	Kayaalt et al. (2019)	✓	✓	✓	✓	✓	x	✓	✓	✓	✓	9	High
14	Lai et al. (2017)	✓	✓	✓	x	✓	✓	x	✓	✓	x	7	Moderate
15	Moitra et al. (2016)	✓	✓	✓	✓	✓	x	x	✓	✓	x	7	Moderate
16	Mujagic et al. (2018)	✓	✓	✓	✓	✓	x	✓	✓	✓	✓	9	High
17	Ono et al. (2019)	✓	✓	✓	✓	✓	x	✓	✓	✓	✓	9	High
18	Pita et al. (2019)	x	✓	✓	x	✓	✓	✓	✓	✓	✓	8	High
19	Richey et al. (2018)	✓	✓	✓	✓	✓	✓	x	✓	✓	✓	9	High
20	Toptas et al. (2018)	✓	✓	✓	x	✓	x	✓	✓	✓	✓	8	High
21	Trivedi et al. (2019)	✓	✓	✓	x	✓	✓	x	✓	✓	✓	8	High
22	Viglianti et al. (2018)	x	✓	✓	✓	✓	✓	x	x	✓	x	6	Moderate
23	Young et al. (2017)	✓	✓	✓	x	✓	✓	✓	✓	✓	✓	9	High
24	Yu et al. (2016)	✓	✓	✓	✓	✓	x	✓	✓	✓	✓	9	High
25	Zarrizi et al. (2021)	✓	✓	✓	x	✓	✓	✓	✓	✓	✓	9	High

Table 4: Data extraction table.

No	Author/ year	Title	Aim	Country/ setting	Methods (design)	Sample	Result
1	Akavipat et al. 2016.	Parameters affecting length of stay among neurosurgical patients in an intensive care unit	To determine the predictive factors on the length of stay of neurosurgical patients in the ICU setting.	Prasat Neurological Institute, Bangkok, Thailand	Observational study.	A total of 276 patients were admitted to the neurosurgical ICU and were involved in this study	The mean and median of ICU length of stay was 2.36 and 2 days. The variables associated with ICU length of stay and their percent change were the Glasgow Coma Scale motor sub score 6.72%, blood pH, 1.16%, and emergency admission type, 58.30% higher as compared to elective admission.
2	Afl-Aftar et al. 2019	Impact of bleeding complications on length of stay and critical care utilization in cardiac surgery patients in England	Evaluation of the impact of bleeding on length of stay and critical care utilization in a nationwide sample of cardiac surgery patients treated at English hospitals.	Hospital episode statistics admitted patient care data warehouse and the clinical practice research datalink. It contains administrative records for all inpatient stays at national health service hospitals in England	Retrospective, observational cohort study using linked English hospital episode statistics and Clinical Practice Research Datalink (CPRD) records.	The study included 7774 eligible cardiac surgery patients	Mean LOS was 10.7d, including a mean of 4.2d in critical care. Incidences of in-hospital bleeding complications and reoperation for bleeding were 6.7% and 0.3%, respectively. Patients with bleeding had longer LOS (MID: 3.1d; p<0.0001) and spent more days in critical care (MID: 2.4d; p<0.0001). Reoperation for bleeding was associated with larger increases in LOS (MID=4.0d; p=0.002) and days in critical care (MID=3.2d; p=0.001).
3	Barrie et al. 2019	Patients with a prolonged intensive care unit length of stay have decreased health-related quality of life after cardiac surgery	To investigate the potential need for intervention in these high risk patients through comprehensive health-related quality of life assessments in the months to Year following their surgery.	St. Boniface Hospital, University of Manitoba, Canada.	A prospective, observational cohort study.	Total of 789 cardiac surgical procedures were performed at St. Boniface Hospital of which 89 patients were identified as having a prolonged ICU length of stay.	At the 3-6 month follow up the prolonged ICU length of stay patients had higher levels of weight loss, fear of falling, and driving deficits. At 1 year, prolonged ICU length of stay patients had persistent difficulties with activities of daily living and required more family and external support.
4	Çevik et al. 2019	Prolonged stay in intensive care unit: retrospective analysis of predisposing factors and outcome	To discuss the factors affecting the prolonged stay in ICU.	Turkey	Retrospective study.	Between 2015and 2017, 219 patients were evaluated retrospectively. The factors affecting of the prolonged stay in ICU were evaluated in respect of age, gender, the reason of admission, length of stay, duration of mechanical ventilation, requiring renal replacement therapy, tracheotomy, blood transfusion, inotropic and vasopressor agents and identified infection	The percentage of the prolonged stay in ICU was 14.56% of overall admissions. The mean age of the patients was 64.74 ± 18.18 years and the age is a predictive factor for the prolonged stay. High APACHE II score (p=0.000), duration of mechanical ventilation (p=0.025), renal replacement therapy (p=0.000), tracheotomy (p=0.25) and inotropic and vasopressor agents requirements (p=0.000) were the other predictors of the prolonged stay in ICU

5	Chacon et al. 2019	Effect of critical care complications on perioperative mortality and hospital length of stay after hepatectomy: A multicenter analysis of 21,443 patients	To determine predictors of critical care complications in patients undergoing hepatectomy.	Data retrieved from a database, The American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP)	All hepatectomy patients in NSQIP from 2012 to 2016 were analyzed. critical care complications included prolonged ventilation (>48h), sepsis/ septic shock, renal failure/ insufficiency, cardiac arrest and pulmonary embolism.	Total of 21,443 patients underwent hepatectomy during the study period.	Overall rate of critical care complications was 11%, with the most common being sepsis/septic shock (6.1%) and respiratory failure (4.9%). On multivariate analysis the preoperative risk factors associated with critical care complications included ASA Class IV-V (OR:2.04, p<0.0001), diabetes (OR=1.28, p=0.0001), pre-operative ventilator use (OR: 17.75, p=0.0003); COPD (OR: 1.65, p<0.0001); pre-operative weight loss >10% (OR: 1.35, p=0.0026); pre-operative sepsis (OR: 2.14, p<0.0001). Propensity score matched analysis demonstrated a significant increased risk of mortality in patients with critical care complications (OR: 26.75, p<0.0001) and a prolonged LOS of 10.5 days above the mean.
6	Diab et al. 2017	Quality of life in relation to length of intensive care unit stay after cardiac surgery	To review the literature regarding quality of; ife outcomes in relation to prolonged ICU stay after cardiac surgery and to explore predictors of poor QOL outcomes.		Systematic review was designed and reported following the PRISMA criteria. All searches were completed on September 17,2015. A systematic review process of published original research articles was conducted.	Studies including patients 18 years or older, undergoing all types of cardiac surgery, and who were admitted to ICU after surgery were included.	Studies including patients 18 years or older, undergoing all types of cardiac surgery, and who were admitted to ICU after surgery were included.
7	Diab et al. 2018	The influence of prolonged intensive care stay on quality of life, recovery, and clinical outcomes following cardiac surgery: A prospective cohort study	To examine the influence of prolonged intensive care unit (ICU) stay on quality of life and recovery following cardiac surgery.	St George's Hospital, London, United Kingdom.	A prospective, single-center longitudinal observational cohort study.	Consecutive patients undergoing elective and urgent cardiac surgery between October 2013 and September 2015 were invited to participate. Total of 608 patients were studied.	For quality of life, the physical component improved over time in both groups, as did the mental component. The long ICU group had lower physical and mental components over Time, but by 12 months the values were similar. The overall quality of recovery was lower for the long ICU group. Major adverse cardiac and cerebrovascula events, 30-day mortality, and length of wad stay were all higher with prolonged ICU stay.

8	Evans et al. 2018	The impact of reducing intensive care unit length of stay on hospital costs: evidence from a tertiary care hospital in Canada	To use theoretical modelling exercises to determine the effect of reduced intensive care unit length of stay on total hospital costs at a Canadian center.	The Ottawa Hospital, Canada.	Retrospective cost analysis.	Total of 30,483 ward encounters and 2,239 ICU encounters.	The mean daily VD cost per ICU patient was $2,472 (CAD), accounting for 67.0% of total daily ICU costs per patient and $717 for patients admitted to the ward. Variable direct cost is greatest on the first day of ICU admission ($3,708), and then decreases by 39.8% to plateau by the fifth day of admission. Reducing LOS among patients with ICU stays ≥ four days could potentially result in an annual hospital cost saving of $852,146 which represents 0.3% of total in-patient hospital costs and 1.2% of ICU costs.
9	Higuchi et al. 2020	Prolonged intensive care unit stay following transcatheter aortic valve replacement	To evaluate ICU stay after TAVR, to identify predictors of PICUS, and to examine the effect of PICUS on short- and long-term prognoses.	Sakakibara Heart Institute, Japan	Retrospective design.	256 consecutive patients.	Length of ICU stay was 2.6 + 4.9 days, and PICUS was identified in 14.7% of the patients. The predominant reason for prolonged ICU stay was congestive heart failure or circulatory failure (41.7%). Pulmonary dysfunction and nontransfemoral approach were independent predictors of prolonged ICU stay (pulmonary dysfunction: nontransfemoral approach). Prolonged ICU stay was associated with higher rate of 30-day combined end point (prolonged ICU stay vs non-PICUS: 44.4% vs 3.3%), longer postoperative hospital stay (49.9+141.9 days vs. 12.0+6.0 days), and lower rate of discharge home (77.8% vs 95.2%). Patients with prolonged ICU stay had worse long-term survival, and prolonged ICU stay was a predictor of mortality.
10	Hosokawa et al. 2015	Timing of tracheotomy in ICU patients: A systematic review of randomized controlled trials	A systematic review was performed to clarify the potential benefits of early versus late tracheotomy.		Systematic review was conducted according to the preferred reporting items for systematic reviews and meta-analyses (PRISMA) statement.		Of the 142 studies identified in the search, 12, including a total of 2,689 patients, met the inclusion criteria. The tracheotomy rate was significantly higher with early than with late tracheotomy. Early tracheotomy was associated with more ventilator-free days, a shorter ICU stay, a shorter duration of sedation and reduced long-term mortality than late tracheotomy.

11	Johnston et al. 2017	Postoperative hypoglycemia is associated with worse outcomes after cardiac operations	To examine the effects of postoperative hypoglycemia, hyperglycemia, and their interaction on short-term morbidity and mortality.		patients undergoing cardiac operations from 2010 through 2014.		
12	Kapadohos et al. 2017	Determinants of prolonged intensive care unit stay in patients after cardiac surgery: a prospective observational study	To identify perioperative factors which prolong stay in ICU.	The surgical ICU at Onassis Cardiac Surgery Center, Athens, Greece.	A prospective observational study.	Total of 145 consecutive adult patients.	During the study period 145 adult patients underwent cardiac surgery: 65 (45%) underwent coronary artery bypass graft surgery, 38 (26%) valve surgery, 26 (18%) combined surgery and 16 (11%) other types of cardiac operation. Seventy-nine (54%) patients had an ICU stay of less than 24 hours. Random forests analysis identified four variables that had a major impact on the Length Of Stay (LOS) in ICU; these variables were subsequently entered in a logistic regression model: preoperative hemoglobin (odds ratio (OR)=0.68), duration of aortic clamping (OR =1.01) and ratio of arterial oxygen partial pressure to inspired oxygen fraction (PaO2/FiO2) (OR =0.99) and blood glucose during the first four postoperative hours (OR=1.02). ROC curve analysis showed an AUC=0.79, P<0.001, 95% CI: 0.71-0.86.
13	Kayaaltı et al. 2019	Risk factors affecting the length of intensive care unit stay after brain tumor surgery	To identify the risk factors that can be used to estimate the need for intensive care stay of more than 1 day for patients with brain tumor resection.	Beijing Tiantan Hospital, Beijing, China.	A retrospective study.	Patients, undergoing intensive care after elective craniotomy and performed in accordance with the Helsinki Declaration principles.	Thirty nine (9.75%) patients and 361 (90.25%) patients were assigned to the long-term intensive care need group and short-term intensive care need group, respectively. In the multivariate binary logistic regression model, the increase in total intravenous anesthesia and patient controlled analgesia applications decreases the patients' long-term intensive care need likelihood while being intubated at ICU admission, need of mechanical ventilation, postoperative hematoma formation, and increased duration of anesthesia increase the patients' long-term intensive care need likelihood.

14	Lai et al. 2019	Prognosis of patients with acute respiratory failure and prolonged intensive care unit stay	To investigate outcomes and identify risk factors of patients with acute respiratory failure who required a prolonged intensive care unit stay (>/=21 days).	Chi Mei Medical Center, China.	Retrospective study.	1,189 patients.	We identified Sepsis (n=896, 75.4%) was the most common cause of prolonged ICU stays, following by renal failure (n=232, 19.5%), and unstable hemodynamic status vasopressors or arrhythmia (n=208, 17.5%). Using multivariable logistic regression, we identified eight risk factors of death: age >75 years, ICU stay for more than 28 days, APACHE II score ≥ 25, unstable hemodynamic status, renal failure, hepatic failure, massive gastrointestinal tract bleeding, and using a fraction of inspired oxygen ≥ 40%. The overall in-hospital mortality rate was 53.6% (n=637), and it up to 75.3% (216/287) for patients with at least three risk factors.
15	Moitra et al. 2016	Relationship between icu length of stay and long-term mortality for elderly ICU survivors	Data from Medicare Standard Analytic Files from the Centers for Medicare and Medicaid Services.		Retrospective cohort study.	Total of 34,696 Medicare beneficiaries. Random sample.	Among 34,696 patients who survived to hospitaldischarge, the mean ICU length of stay was 3.4 (± 4.5) days. 88.9% of patients were in the ICU for1–6 days, representing 58.6% of ICU bed-days. 1.3% of patients were in the ICU for 21+ days, but these patients used 11.6% of bed-days. The percentage of mechanically ventilated patients increased with increasing length of stay (6.3% for 1–6 days in the ICU and 71.3% for 21+ days). One-year motality was 26.6%, ranging from 19.4% for paients in the ICU for one day, up to57.8% for patients in the ICU for 21+ days. For each day beyond seven days in the ICU, there was an increased odds of death by 1-year of 1.04 (95% CI 1.03–1.05) irrespective of the need for mechanical ventilation.

16	Mujagfic et al. 2018	Associations of hospital length of stay with surgical site infections	Identifying the associations of pre- and postoperative LOS in hospital and intensive care with the occurrence of surgical site infection.	The University Hospital of Basel and the hospital of Aarau, two tertiary referral centers in Switzerland.	Observational cohort study.	5175 patients	4596 patients, 234 of whom (5.1%) experienced SSI. Being admitted at least 1 day before surgery compared to same-day surgery was associated with a significant increase in the odds of surgical site infection in univariate analysis (OR 1.65, 95% CI 1.25–2.21, p\0.001). More than 1 day compared to 1 day of preoperative hospital stay did not further increase the odds of SSI (OR 1.08, 95% CI 0.77–1.50, p=0.658). Preoperative admission to an Intensive Care Unit (ICU) increased the odds of surgical site infection as compared to hospital admission outside of an ICU (OR 2.19, 95% CI 0.89–4.59, p=0.057). Adjusting for potential confounders in multivariable analysis weakened the effects of both preoperative admissions to hospital (OR 1.38, 95% CI 0.99–1.93, p=0.061) and to the ICU (OR 1.89, 95% CI 0.73–4.24, p=0.149).
17	Ono et al. 2019	Predicted clinical factors associated with the intensive care unit length of stay after total cavopulmonary connection	To determine the clinical risk factors for ICU-LOS.	German Heart Center, Munich, Germany.	Single-center retrospective cohort study.	483 patients who underwent a total cavopulmonary connection between May 1994 and December 2016 were included the study	Of hemodynamic variables, preoperative high transpulmonary gradient (P ¼ .037), and low aortic oxygen saturation (P ¼ .031) were risks for longer ICU LOS. Of postoperativevariables, pleural effusion (P<.001), chylothorax (P ¼ .001), ascites (P<.001), and infection (P ¼ .028) were risks for longer ICU LOS. The ICU LOS was found to be significantly assocated with late mortality (P<.001) and late ardiac reoperation.
18	Pita et al. 2019	Variability in intensive care unit length of stay after liver transplant: Determinants and potential opportunities for improvement	To use an assessment tool to determine if LT recipients remain in ICU beyond designated indications		Records from 100 consecutive LTs performed in a single institution were retrospectively reviewed.	A retrospective analysis was conducted on 100 consecutive adult LTRecipients who underwent transplantation between April 2016 through February 2017 in a single liver transplant center.	Mean age 55 years (range 24–78 years) and mean Model For End-Stage Liver Disease score 30 (range 6–47). Three recipients who died within one week were excluded. Forty-eight (49.5%) patients had a total of 75 additional days on initial ICU stay. Univariate analysis revealed no significant differences between patients with and without additional days.

19	Rfichey et al. 2018	implementation of an early extubation protocol in cardiac surgical patients decreased ventilator time but not intensive care unit or hospital length of stay	The optimal timing of extubation following cardiac surgery is currently unknown. Protocols implemented in order to achieve a rapid extubationmay achieve this goal, but not prove beneficial in terms of outcomes.	Tertiary care cardiac surgical intensive care unit.	A prospective clinical trial.	459 patients adult cardiac surgical patients.	In all 459 patients were included in the study. With implementation of the protocol, median ventilation times decreased from 7.4 hours to 5.73hours. However, median ICU length of stay in patients who achieved extubation within 6 hours increased to 49.45 hours from 40.3. Median hospital length of stay was not significantly changed due to the protocol in any ventilation tertile.
20	Toptas 2018	Factors affecting the length of stay in the intensive care unit: our clinical experience	To identify and categorize the factors associated with prolonged stays in ICU.	The Haseki training and research hospital, Turkey.	Retrospective study.	Total of 3925 patients.	The mean age of the study was 61.6 ± 18.9 years. The average length of stay in intensive care unit was 10.2 ± 25.2 days. The most common cause of hospitalization was because of multiple diseases (19.5%). The length of stay was positively correlated with urea, creatinine, and sodium. It was negatively correlated with uric acid and hematocrit levels. Length of stay was significantly higher in patients not operated on than in patients operated.
21	Trivedi et al. 2019	Survival, quality of life, and functional status following prolonged ICU stay in cardiac surgical patients: a systematic review.	To systematically review the outcomes of cardiacsurgical patients requiring prolonged intensive care with respectto survival, residential status, functional recovery, and quality of life in both hospital and long-term follow-up.		Studies were included if they assessed hospital or long-term survival and/or patient-centered outcomes in adult patients with prolonged ICU stays following major cardiac surgery. After screening 10,159 citations, 114 articles were reviewed in full; a final 34 articles met criteria for data extraction.		Twenty-eight studies observed greater in-hospital mortality among all levels of prolonged ICU stay. Twenty-five studies observed greater long-term mortality among all levels of prolonged ICU stay. Multiple tools were used to assess patient-centered outcomes. Long-term health-related quality of life and function was equivalent or worse with prolonged ICU stay.
22	Vigliani et al. 2018	Late organ failures in patients with prolonged intensive care unit stays	To characterize the organ failures that develop among patients with prolonged ICU stays, defined as those who spent a minimum of 14 days in an ICU.	University of Michigan, United States.	Retrospectively study.	Cohort of consecutive patients from a university hospital who were in an ICU for a minimum of 14 days during 2014-2016.	Cohort of 3777 consecutive patients in six ICUs, 50 patients had prolonged ICU stays. Of those 50, new cardiovascular failure occurred in 24 (62%) on day 4 or later; persistent mechanical ventilation was present in only 28 (56%).

23	Young et al. 2017	Does length of intubation before tracheostomy affect intensive care unit length of stay?	To determine if length of intubation prior to tracheotomy affects length of stay in intensive care unit	Grady Memorial Hospital, United States.	A retrospective case series of patients who had open tracheotomies.	Patients receiving open tracheostomies by Emory OMS service at Grady Memorial Hospital from November 2010 to November 2014. Patients were included if they received tracheostomy by Emory OMS. The exclusion criterion was incomplete medical records.	There were 115 subjects with mean age 54 years old. Majority of patients (N=100, 87%) received tracheotomies due to prolonged mechanical ventilation secondary to medical comorbidities.
24	Yu et al. 2016	Outcomes of patients with prolonged intensive care unit length of stay after cardiac surgery	To determine in-hospital and post-discharge long term survival in patients with prolonged intensive care unit stays after cardiac surgery.	Single center cardiac surgery ICU.	Retrospective cohort study of cardiac surgery patients from 5-2007 to 6-2012.	Patients were grouped according to length of ICU stay: between 1 to 2 weeks, between 2 to 4 weeks and >4 weeks	Total of the 4963 patients, 3.3%, 1.6% and 2.9% of patients stayed 1 to 2 weeks, 2 to 4 weeks, and >4 weeks in the ICU, respectively. Patients with ICU stays between 1 to 2 weeks have 6 months, 1 year, and 2-year survival rates of 84.4%, 80.0%, and 75.3% after discharge, respectively. Patients with ICU stay between 2 and 4 weeks have similar 6 months, 1 year, and 2-year survival rates of 84.7%, 79.9%, and 74.1%, respectively. In contrast, patients with >4-week ICU stays have significantly lower post-discharge survival rates of 63.3%, 56.4%, and 41.1% at 6 months, 1 year, and 2 years, respectively.
25	Zarrizi et al. 2021	Predictors of length of stay in intensive care unit after coronary artery bypass grafting: development a risk scoring system	To determine in-hospital and post-discharge long term survival in patients with prolonged intensive care unit stays after cardiac surgery.	Rasht, northern Iran.	Observational retrospective study.	Patients over 18 years of age, undergoing CABG without history of previous cardiac surgery and intra-aortic balloon pump (IABP) use, and who were admitted to ICU after surgery were included in the investigation.	The mean ICU LOS after CABG was 55.27 ± 17.33 hours. Cox regression model showed that having more than two chest tubes (95% confidence interval (CI) 1.005-1.287, Relative Risk (RR=1.138), occurrence of atelectasis (95% CI 1.000-3.007, RR=1.734),and occurrence of atrial fibrillation after CABG (95% CI 1.428-2.424, RR=1.861) were risk factors associated with longer ICU LOS.

Results

Characteristics of the reviewed studies

Overall, twenty-five studies have met the inclusion criteria. Of the twenty-five studies, nineteen have been found to have a retrospective design; also three of the included studies used an observational cohort design. In addition, three studies had a prospective study design. However, two studies did not mention which design was used [18,19]. The largest sample size was found in a study by Moitra with a sample size of 34.696 participants. In contrast, the smallest sample size was found in a study by Pita A with a sample compromised of 100 participants [20].

Several themes were identified from the given review. The primary themes found are; preoperative factors associated with prolonged ICU-LOS among surgical patients, intraoperative and postoperative factors associated with prolonged ICU-LOS among surgical patients, the impact of intubation and use of Mechanical

Ventilator (MV) on ICU-LOS, and outcomes of prolonged ICU-LOS.

Theme 1: Preoperative Factors Associated With Prolonged ICU-LOS among Surgical Patients

A study by Chacon involved 21,443 post keratectomy patients, the results of this study showed that patients who developed at least one critical care complication had an increased ICU-LOS of 11 days compared to the group who did not develop critical care complication with a mean ICU-LOS of 5 days. It was reported that most of the patients who developed critical care complications after surgery were either smokers (18%), a history of COPD (61%), also had higher rates of medically treated diabetes mellitus, hypertension, and preoperative sepsis/SIRS. This study also showed that there are some preoperative factors may be relevant to increase the risk of developing critical care complication, including; preoperative use of Mechanical Ventilator (MV), use of steroid medications, and preoperative significant weight loss.

According to a prospective observational study in Athens, Greece by Kapadohos [21] on post-cardiac surgery patients in ICU, low preoperative hemoglobin is a risk factor for a prolonged ICU-LOS, it will cause an increment in usage of hospital resources, mainly due to the need of blood transfusion which might have a significant effect on increasing ICU-LOS after cardiac surgery.

Akavipat study among neurosurgery patients in ICU, showed that some biochemical variables, especially pre-surgery pH balance that affects ICU-LOS because of its effect on impairing cerebral blood flow and vascular reactivity of cerebrovascular. Thus, these events may lead to poor clinical outcomes as well as increasing ICU-LOS. In addition, it was reported in this study that the Glasgow Coma Scale (GCS) evaluated in the pre-admission assessment for neurological deterioration, was determined as a strong predictor of prolonged ICU-LOS for neurosurgical patients.

Similarly, Kayaaltı et al., conducted a study exploring risk factors affecting ICU-LOS among brain tumor patients, even though only 9.75% of the patients participated in this study had prolonged ICU-LOS when GCS scores were calculated for post elective craniotomy patients, it was found that patients with long ICU-LOS had significantly lower GCS scores when compared to patients with short term ICU-LOS. Also, other factors such as the requirement of an endotracheal tube and MV, intraoperative bleeding, serum glucose level less than 10 mmol/l, and high serum glucose level were found to have an effect in increasing ICU-LOS [22].

The study of Pita et alreported that approximately 60% of liver transplant patients require pre-transplant ICU admission, most because of requiring renal replacement therapy and/or vasopressors support, which is reflected in the postoperative prolonged ICU-LOS.

Theme 2: Intraoperative and Postoperative Factors Associated With Prolonged ICU-LOS among Surgical Patients

Intraoperative factors affecting ICU-LOS in neurosurgical patients were identified by Akavipat as perioperative transfusion and the location of the lesions in the brain. Chacon et al., have found that patients who underwent elective hepatectomy who also developed at least one critical care complication postoperatively had a LOS doubling the LOS of non-complicated patients. The most common factors highly associated with critical care complications were infected wounds, trisectionectomy for liver transplantation preparation then the presence of a history of COPD, respectively.

A significant prospective observational study by Kapadohos in Greece has identified the most common postoperative complications were to found to occur during the first 24 hours were mainly secondary to blood loss, pulmonary dysfunction, arrhythmias, re-intubation, and cardiac arrest.

Furthermore, a study by Higuchi was conducted retrospectively on patients post Transcatheter Aortic Valve Replacement (TAVR) in Japan, found that prolonged ICU stay was found in 14.7% of the patients studied, and the most common reason for prolonged ICU-LOS was congestive heart failure or circulatory failure.

Hemorrhage or excessive bleeding was considered to be of a significant predictor for LOS. A study by Al-Attar in England, found that the mean postoperative LOS for patients who had bleeding complications intraoperative or postoperative was 15.4 days. In addition, 87% of patients who experienced bleeding complications spent at least one or more days in ICU post-surgery, compared with 82% of patients who did not have any bleeding complications. In this study, the type of cardiac surgery affected the incidence rate of bleeding. The highest rate of bleeding complications was associated with aortic procedures with a percentage of 15%, followed by multiple cardiac procedures with 12.1%, valve replacement and repair (5.9%), then CABG (5.1%). Another factor was studied, which is the need for reoperation for bleeding complications; it has been found that the mean LOS increased to 14.7 days in contrast to 10.7 days in patients who did not need a reoperation. This study agreed with Kapadohos in the factor of bleeding and blood loss postoperatively had a major effect on the contribution of prolonging ICU-LOS [23].

On the other hand, a Swiss study by Mujagic found that there is a relationship between pre and postoperative ICU admission and the occurrence of Surgical Site Infection (SSI) which is a risk factor for an increased ICU-LOS [24].

Similarly, a retrospective study was conducted in China by Lai that showed that the most common cause of prolonged ICU-LOS was sepsis (75.4%), followed by renal failure (19.5%), then arrhythmia or unstable hemodynamic status requiring the use of vasopressors (17.5%), followed by severe gastrointestinal tract bleeding (9.7%), then using FiO2 ≥ 40% (9.3%), needing another subsequent surgery (7.0%), hepatic failure (4.5%) and using PEEP ≥ 10 cmH2O (4.5%). These factors led to an increment of the patients' ICU-LOS for more than 28 days in 44.8% of them.

A Turkish study by Çevik et al., agreed with Mujagic et al., in a sense that patients who were infected had approximately 3-times longer in ICU than the uninfected patients [25].

As well as a study about predicting clinical factors associated with increased ICU-LOS for patients post total cavopulmonary palliative procedure for repair of congenital heart diseases. Ono reported that the main causes of the prolonged ICU-LOS were ascites, chylothorax, and pleural effusion. It was found that increased ICU-LOS to be highly associated with late reoperation and late mortality [26].

Furthermore, Toptas study reported the ICU-LOS for postoperative patients was shorter than the ICU-LOS for patients admitted for other reasons. Also, it was found that electrolytes disturbances such as increased value of sodium, urea, and creatinine were correlated to the increased ICU-LOS [27].

Yu et al., had a study that found that postoperative stroke is the strongest predictor of poor prognosis after hospital discharge in cardiac surgery patients with a prolonged postoperative ICU-LOS. It also found that the predictors of increased ICU-LOS post-cardiac surgery include older age, gender, diabetes mellitus, heart failure, preoperative renal function, presence of chronic obstructive pulmonary disease, cerebrovascular disease, atrial fibrillation, need for reoperation, obesity, type of operation, length of operation, and need for blood transfusions [28].

Johnston et al., studied the effect of postoperative hypoglycemia on ICU-LOS, and found that hypoglycemia after cardiac surgeries were associated with increased respiratory adverse events and increased ICU-LOS. It was also suggested in this study that the large variability in glycemic levels can indicate more risk for increased ICU-LOS and adverse outcomes.

According to Zarrizi et al, who did a study to determine the predictors of ICU-LOS after Coronary Artery Bypass Grafting (CABG), reported that one of the common predictors was atelectasis, which was also a common respiratory complication after cardiac surgery. Inactivation of lungs due to the prolonged usage of cardiopulmonary pump during open-heart surgery can result in aggravation of respiratory complications. The superficial breathing of the patient because of sternum incision pain, and the inability of the lung to adequately participate in the breathing process following atelectasis, can cause the patient's respiratory insufficiency. These complications seem to be a predictor for prolonged longer ICU-LOS after CABG [29].

Another study by Pita et al., reported that there are some common postoperative complications in post liver transplant patients that may lead to increased ICU-LOS and use of resources including infections, renal failure that requires renal replacement therapy, and respiratory failure. Furthermore, 23-27% of the increased ICU days after the acute care were unnecessary interventions due to the need for postoperative fluid and renal function monitoring. Also, monitoring of neurologic and altered mental status was another major reason for the additional days in ICU, 17%of the total additional ICU days were due to liver transplant surgery patients suffered from delirium, seizures, or metabolic encephalopathy.

Theme 3: Impact of Intubation and Use of Mechanical Ventilator on ICU-LOS

A retrospective study in Turkey by Çevik et al., aimed to discuss the factors affecting the prolonged ICU-LOS, has found that there was a correlation between the duration of MV and prolonged ICU-LOS. The prolonged MV duration was associated with infection which may predict worse prognosis.

Furthermore, a prospective clinical trial by Richey et al., applied a protocol on 459 adult post-cardiac surgery patients; it aimed to achieve extubation within 6 hours on postoperative cardiothoracic surgical ICU patients. It showed that the success in the implementation of early extubation did not result in a reduction of ICU-LOS; actually, ICU hours increased by a median of 5 hours. The results showed that patients who were intubated within 6 hours had an increased risk of developing renal failure following the application of the protocol. This study also found that patients who were suffering from systolic heart failure preoperatively had a longer ICU-LOS with a median of 60.3 hours [30].

In Moitra et al., retrospective study, most of the patients who survived after admission to ICU were not connected to mechanical ventilator with a percentage of 90.0%. Moreover, 60% of the patients who stayed in ICU for more than seven days were not mechanically intubated. Whereas the majority of patients who needed mechanical ventilator were surgical patients.

Young et al., study supported that early tracheostomy may reduce ICU-LOS, sedation, hospital costs, and promote earlier feeding [31]. Also, a systematic review conducted by Hosokawa et al., examined 12 randomized controlled trials that compared between early tracheotomy that was done within 4 days of initiation of mechanical ventilation, to relatively early tracheotomy within 10 days of initiation of mechanical ventilation, and to late tracheotomy which was after 10 days. The result showed that a total of 2689 patients who had early tracheostomy were associated with better outcomes including decreased ICU stays and fewer days on mechanical ventilator.

Theme 4: Outcomes of Prolonged ICU-LOS

It had been found in a study by Barrie et al. that examine mid-term and long-term functional outcomes in patients with a prolonged ICU-LOS following cardiac surgery. It showed that in the critically ill non-cardiac surgery patients who had a prolonged ICU-LOS, had shown functional disability, which was defined as how much assistance patients need in Activities of Daily Living (ADLs). Meanwhile, the prolonged ICU-LOS cardiac surgery critically ill patient who had been exposed a cardiac surgery before ICU admission, they were susceptible for more intraoperative and postoperative complications, as well as experiencing chronic functional deficits making them at risk for poor functional performance and increased reliance on family and other social support systems.

Viglianti et al., found that among ICU patients with long-stay, persistent critical diseases, four in five developed at least one new late organ failure, most commonly cardiovascular. Respiratory failure developed in only half of the long-staying patients; it was detected by continuous hypoxemia. Re-intubation after estuation was commonly occurring after several days later [32].

Trivedi et al., agreed with Barrie et al. that although only 5%-10% of post cardiac surgery patients experience major morbidity and require prolonged ICU stays, it can be associated with chronic critical illness that consumes remarkable healthcare resources, and also alter functional outcomes and patients quality of life and increase the dependency of patients on their families [33].

On the other hand, Diab et al., reported that the majority of post prolonged ICU-LOS post cardiac surgery patients who survived their hospital stay reported good functional status when their ability to complete activities independently was examined.

Similarly, Diab et al., in another study reported a postoperative decline in cognition in 30%-80% of post cardiac surgery patients with prolonged ICU-LOS, although after 3 months period their cognitive abilities overlapped and showed no differences when compared with patients with normal ICU-LOS [34].

For the financial aspect of prolonged ICU-LOS, Evans et al. have studied the effect of decreasing ICU-LOS on hospital costs in Canada. This study showed that reducing ICU-LOS is proportionally a small source of the total hospital and ICU costs savings. Thus, it did not support the opinion of reducing ICU-LOS is an effective strategy for saving costs [35].

Discussion

Twenty-five articles were involved in this scoping review which provides an overview of what are the predictors of prolonged ICU-LOS among surgical patients. Out of the twenty-five articles, fifteen articles discussed intraoperative and postoperative predictors associated with prolonged ICU-LOS among surgical patients Akavipat et al., study aimed to determine the factors predicting the LOS of neurosurgical patients in the ICU in Thailand, it showed that identifying and understanding these predictors is important to develop strategies to improve and manage patients' outcomes as well as health care facilities costs. Therefore, it was found that the pre-admission assessment of the Glasgow Coma Scale (GCS) is a good predictor for prolonged ICU-LOS post neurosurgery patients. In addition, some biochemical factors were found to affect ICU-LOS especially pH balance, due to its effect in potentially impairing cerebral blood flow. Some intraoperative predictors were identified to affect ICU-LOS as well, such as perioperative need for blood transfusion, the location of brain injury and perioperative complications.

Furthermore, a study by Al-Attar et al., in England, that studied the impact of bleeding on ICU-LOS in post cardiac surgery patients. It showed that postoperative bleeding was associated with increased mechanical ventilator period after cardiac surgery which expecting to prolong ICU-LOS more than 72 hours.The mean LOS post cardiac surgery was 15.4 days for patients who experienced bleeding complications; on the other hand, the mean LOS for post cardiac patients who did not have any bleeding was 10.4 days.

Higuchi et al., study has supported the result in Al-Attar et al., the study was conducted in Japan, and it was about prolonged ICU stay after Trans catheter Aortic Valve Replacement (TAVR). It showed that retroperitoneal hemorrhage was one of the reasons for prolonged ICU-LOS in post TAVR patients. However, it was found that the most common reason for the prolonged ICU-LOS was congestive heart failure, circulatory failure, and Acute Kidney Injury (AKI). It was also found that the patients who had prolong ICU-LOS had a high possibility for longer postoperative hospital stay associated with a lower rate to be discharged home.

Ono et al., study reported that the most comorbidity associated with prolonged ICU-LOS was postoperative pleural effusion, even though the underlying mechanism was poorly understood, it is considered as a marker for low hemodynamic status.

A study that investigated the outcomes of postoperative hypoglycemia after cardiac surgeries by Johnston in the United States indicated that hypoglycemic episodes post cardiac surgeries were associated with increased respiratory complications, thus had an increased ICU-LOS. In addition, Toptas conducted a retrospective study in Turkey to identify factors associated with increase ICU-LOS. It has been reported that the increased values of sodium, keratinize, and urea were associated with prolonged ICU-LOS.

A retrospective study in China by Lai et al., aimed to investigate outcomes and risk factors of patients with Acute Respiratory Failure (ARF) with prolonged ICU-LOS. The results of this study showed that out of 1189 patients who were included in the study, 721 (60.6%) patients were identified with ARF who had prolonged ICU-LOS. However, it was concluded in this study that the outcomes of patients with ARF who had prolonged ICU-LOS were poor.

Another study by Çevik et al., in Turkey has explored the predisposing factors and outcomes of prolonged ICU-LOS, it reported that duration of MV, infection, requiring renal replacement therapy, need for inotropic and vasopressors support, and presence of tracheotomy were found as predictive factors for a prolonged ICU-LOS. However, infection as a predictor for prolonged length of stay was also studied by Mujagic et al., who investigated SSI as an outcome for prolonged ICU-LOS. It was found that there was a weak association between ICU admission and SSI.

However, a study by Chacon et al., has explored the effect of Critical Care Complications (CCCs) on perioperative mortality and ICU-LOS in post hepatectomy patients. It was found that 11% among all included patients has developed at least one CCC. The most common CCCs developed were sepsis/septic shock and respiratory failure.

A retrospective study was conducted in China by Kayaaltı et al., identify the risk factors to estimate prolonged ICU-LOS. The result of this study showed that age, endotracheal intubation, and the need for MV with other major postoperative complications were associated with prolonged ICU-LOS. Also, it was found that longer anesthesia duration was associated with increased postoperative complication incidences, thus increased ICU-LOS. In addition, it was reported that minor intraoperative bleeding and the need for 1-2 units of blood transfusion were highly associated with prolonged ICU-LOS.

Yu et al., has conducted a retrospective cohort study on post cardiac surgery patients, investigated the outcomes of patients with prolonged ICU-LOS. The results of the study showed that 7.8% of the participants in the study who underwent open-heart surgery and CABG stayed more than one week in the ICU, therefore increased age, history of cerebrovascular diseases, and the need for reoperation were found to be associated with increased ICU-LOS. Thus increasing the incidences of pneumonia, renal failure, sepsis, and gastrointestinal complications.

Another study in Iran was done by Zarrizi et al., to determine predictors of ICU-LOS after CABG. The results showed that the ICU-LOS in one-third of the included patients in the study was

longer than the mean ICU-LOS. Also, the results of this study had identified the occurrence of atrial fibrillation after CABG as a predictor of prolonged ICU-LOS. Atrial fibrillation was found to occur in around 35% of post cardiac surgery cases.

Four articles have reported preoperative low hemoglobin, preoperative hyperglycemia, need for vasopressors use, need for preoperative renal replacement therapy etc., are considered some of the preoperative factors that affect the ICU-LOS among surgical patients.

Chacon et al., has reported that some preoperative conditions may contribute to increasing the occurrence of CCCs post hepatectomy thus prolonging ICU-LOS, it included steroid therapy, chronic conditions such as Diabetes Mellitus (DM), hypertension, preoperative use of MV and the presence of preoperative sepsis.

A prospective observational study by Kapadohos et al., conducted in Greece, aimed to identify perioperative factors which prolong ICU-LOS. It was found that low preoperative hemoglobin level increases the likelihood of the need for preoperative blood transfusion, which may cause some adverse events leading to increased ICU-LOS.

Four articles involved reporting of the negative impact of prolonged ICU-LOS. In Viglianti et al., study it was found that 50 patients with ICU-LOS longer than 14 days, 24 patients (48%) of the patients had more than one organ failure between days four and fourteen and the most common newly developed late organ failure was cardiovascular failure in 61.5% of the patients. Furthermore, Barrie et al., have reported that patients with prolonged ICU-LOS had more intraoperative and postoperative complications that increase patients' mortality rate, also experience some long-term functional deficits placing the patients at risk for increased reliance on others and poor functional status.

In contrast, Diab et al. studies both found that even though patients with prolonged ICU-LOS had a decline in their functional status and cognition postoperatively, however it had been reported that there was regaining of good functional and cognitive status after a period from the operation.

Financially wise, a retrospective study in Turkey by Evans et al., to explore factors affecting ICU-LOS, reported that among patients who stayed in ICU for more than four days, reducing ICU-LOS by one day resulted in cost savings of 852.146$ which was 1.2% of ICU costs.

Regarding the quality of life, Trivedi et al., studied the quality of life and functional status after prolonged ICU-LOS among post cardiac surgery patients. Patients with prolonged ICU-LOS showed either equivalent or worse health-related quality of life when compared with patients who did not have prolonged ICU-LOS. Even though, most of the cardiac surgical patients who survive after prolonged ICU-LOS have an acceptable functional status with a minor reduction in the physical aspects of health-related quality of life.

However, some researches showed that some patients ICU-LOS was not related to disease acuity as reported by Pita et al., this study found that a large number of post liver transplant patients who no longer required acute critical care management, remained in the ICU with various reasons which were accounted as additional ICU days. Among these reasons, the need for continuous monitoring for respiratory complications and renal dysfunction had a significant role in prolonging ICU-LOS. However, it was found that providing intermediate post liver transplantation care in surgical unit with frequent assessment and specialized training for nursing and health care team members will help to decrease ICU-LOS.

Four articles reported results related to the effect of intubation and MV on prolonging ICU-LOS. A prospective clinical trial study by Richey et al. was conducted to explore the optimal timing for extubation after cardiac surgery in ICU. It showed that even though the researcher was able to exudate most of the patients within six hours which reduced the median ventilation time. However, this achievement of early extubation was not seen in decreasing ICU-LOS nor hospital stays, but actually, ICU-LOS hours increased by a median of 5 hours.

Another study by Moitra et al., aimed to evaluate the relationship between ICU-LOS and mortality rate in elderly patients. This study found that patients who were connected to MV for prolong duration have been identified with a high mortality rate, which resulted in consuming a large proportion of health care resources.

A systematic review was done by Hosokawa et al., to clarify the benefits of early and late tracheostomy. The results showed that early tracheostomy is associated with less duration of sedation and decreased ICU-LOS. In addition, Young et al., has explored the effect of length of intubation before tracheostomy on ICU-LOS. The results reported that early tracheostomy which was performed within seven days of intubation was associated with reduced duration of ICU-LOS and MV time, also it was concluded that early tracheostomy leads to shorter sedation duration, therefore reducing hospital costs by decreasing ICU-LOS.

Knowledge Gap

The majority of the reviewed studies had covered the factors affecting ICU-LOS in the postoperative period. Meanwhile, very few articles had mentioned the factors that may be associated with ICU-LOS in the preoperative and intraoperative period. This was because of the inability to access patient's data or appropriately follows up patients in the preoperative and intraoperative period. Furthermore, other predictors or factors were not thoroughly investigated; such as; patient's age, duration of the operation, hemodynamic instability, and type of anesthesia etc. in prolonging ICU-LOS. In addition, no researches that study neither the predictors of ICU-LOS nor the effect of the prolonged ICU-LOS in Saudi Arabia were done.

Conclusion

In conclusion, this review has identified relevant and significant studies related to the predictors of prolonged ICU-LOS among surgical patients in preoperative, intraoperative, and postoperative periods along with related findings. Most of the reviewed studies involved the postoperative factors that contribute to increasing ICU-LOS, such as; bleeding, intubation, sepsis and use of mechanical ventilator. Scarce of studies were

found related to pre and intraoperative predictors.

Accordingly, skilled and well-trained advanced practiced nurses play a major role in monitoring patients' condition, planning, communicating clinical information, which affects the quality of health care delivery. Thus, having the ability to detect the predictors that may prolong ICU-LOS and provide appropriate management as early as possible is crucial.

Recommendations

It is recommended to conduct further researches to bridge the identified gap in the literature, and to correlate the effect of other common factors and predictors such as age and use of certain medications in prolonging ICU-LOS, and more specifically among Saudi ICU populations. Moreover, the related predictors in the studies that reported to affect the ICU-LOS should be communicated and enforced to nurses related to the profession through guidelines, in order to manage these predictors to reduce ICU-LOS, therefore, improving the quality of care and quality of patients' life.

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