

Rate and Factors Related to Postoperative Intensive Care Unit (ICU) Utilization in Elective Gynecologic Oncology Patients

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Abstract

Background: ICU has played an important role in taking care of patients scheduled for oncologic gynecology surgery; however, information regarding utilization of critical care services and the outcomes of these patients is not well established, particularly in Siriraj hospital. Most of these patients also have medical comorbidities, contributing to complications.

Objective: To determine the rate and factors related to postoperative ICU admission among gynecologic oncology patients with the beforehand ICU reservations and to report the postoperative outcomes.

Materials and Methods: The retrospective single-center study was conducted by reviewing patient charts from April 2013 to March 2020. Preoperative characteristics and intra- and postoperative events were analyzed using logistic regression analysis.

Results: A total of 321 patients who underwent preoperative ICU reservation with complete

medical records were collected. Most of the patients aged <65 years (62.3%) and had American Society of Anesthesiologists (ASA) physical status $\geq$ III (71.3%). Total confirmed postoperative ICU admissions were 90 cases (28%). Factors related to ICU admission included preoperative serum albumin level <3.45 g/dl, intraoperative blood loss >800 ml and urine output <0.5 ml/kg/h. Most common indication of ICU admission and postoperative complication were postoperative observation (48.9%) and acute kidney injury (AKI) (36.7%), respectively.

Conclusion: Albeit low rate of gynecologic oncology patients requiring postoperative ICU admission, vigilant patient evaluation before ICU admission is paramount. This study provides predictors that can be implemented in future guideline for postoperative ICU admission to save the healthcare resources and preserve ICU space for the patients in need.

Keywords: complications, gynecologic oncology, intensive care unit, postoperative admission, reservation

The surgical intensive care unit (ICU) is a worthy resource for oncologic gynecology surgeons and anesthesiologists in the care of their patients. Previous study had reported that 6-36% of gynecologic cancer patients required postoperative ICU admission.¹ However, reports on the utilization of critical care services and the outcomes of these patients are not well established. Ruskin et al. had previously reported factors affecting ICU admission in oncologic gynecology patients. The conclusion from multivariate analysis of the study revealed that Charlson comorbidity index (CCI) score <8 and albumin level <3.5 g/dL could be factors associated with an increased risk of postoperative ICU admission.¹ Moreover, many gynecologic oncology patients also have other significant medical comorbidities, for instance, diabetes, hypertension, cardiac arrhythmias, respiratory failure, presence of ascites and having undergone chemotherapy treatment. These preexisting comorbidities may predispose to high risk of perioperative complications during aggressive surgical treatment and the need of postoperative ICU admission.²⁻⁵

The study concerning the requirement for postoperative ICU admission in oncologic gynecology patients have not previously been conducted in our institution, Siriraj Hospital Faculty of Medicine, Mahidol University. The guidelines or predictors for postoperative ICU admission for patients at risk also have yet to be proposed. Institutional past records demonstrated that there were many cases that, prior to the start of surgical procedures, requested for postoperative ICU admission due to the patients' medical

conditions and/or invasiveness of surgical procedures. However, there were at times cancellations of ICU reservation as a result of uneventful intraoperative events and good postoperative clinical outcomes. According to the fact that the ICUs in our institution adopted the principle of admission in chronological order (first come, first served basis) which was based on the recommendations of the American Thoracic Society Bioethics Task Force⁶, these cancellations could cause a loss of opportunity for immediate postoperative ICU admission for other cases that ICU admission was also necessary. As evidenced by past studies, a delayed postoperative ICU admission could result in increased mortality, hospital length of stay and requirement of advanced respiratory support.⁷⁻¹⁰ The waiting and monitoring areas before transferring until the ICU was available, either post-anesthesia care unit (PACU) or the operation rooms themselves, would be exploited yet with less capacity to treat the patients than ICU.^{7,9,10} Late cancellation might cause other patients in need for ICU to miss the chance of ICU admission and optimal postoperative ICU care. Moreover, caring for the critical patients outside the ICU environment might generate stress and burden to optimal treatment.⁷ Therefore, the aims of this study were to determine the rate of confirmed cases with postoperative ICU admission among all cases with preoperative ICU reservation and the associated factors related to postoperative ICU admission. Postoperative complications of the confirmed ICU cases as well as individual's outcome regarding mortality and organ dysfunction were analyzed and reported.

Materials and methods

This study was a descriptive observational single center-based research conducted by a retrospective electronic chart review of oncologic gynecology patients scheduled for the elective operations between April 2013 and March 2020 at Siriraj Hospital. All of the patients subjected to preoperative ICU reservation were considered for inclusion in the study. Ethical Review Committee for Human Research, Institutional Review Board (IRB), Faculty of Medicine, Siriraj Hospital, Mahidol University (Ethical number Si742/2562) approval was obtained. Exclusion criteria were: 1) patients with incomplete medical records, 2) patients who were previously admitted in the ICU, 3) emergency operation and 4) unplanned ICU admission.

Preoperative underlying diseases were classified and recorded according to organ system of origin. Pre-existing conditions including sepsis ascites, pleural effusion and deep vein thrombosis (DVT), etc. were as well recorded. Intraoperative events were designated according to standard definitions as 1) Hypotension: systolic blood pressure (SBP) <80 mmHg or decreased in SBP >20% from the baseline. An episode of hypotension was defined as a drop in SBP for longer than 5 min, 2) Bradycardia: heart rate <60 beats/min for >5 min, 3) Desaturation: pulse oximetric reading of oxygen saturation <95% for >10 sec, 4) Low urine output: urine output <0.5 mL/kg/h and 5) Hypothermia: core temperature <35°C and 6) Prolonged intubation: patients who remained intubation >72 h.¹¹⁻¹³ Myocardial infarction was diagnosed with a rise in cardiac troponin (cTn) above the 99th percentile of upper

reference limit which indicates acute myocardial injury.¹⁴ Ischemic stroke was described as an episode of neurological deficit as a result of focal infarction. Intracerebral hemorrhage (hemorrhagic stroke) was a rapid deterioration of neurological function caused by an accumulation of blood within the brain parenchyma or ventricular system without evidence of previous trauma. Diagnosis of stroke was based on 1) cerebral imaging or evidence of area of central nervous system infarction corresponding to vascular distribution or 2) clinical evidence of ischemic injury, when other causes are excluded, that persists ≥24 hours.¹⁵ Acute kidney injury (AKI) was a term used for rapid decline in kidney function. Chronic kidney disease (CKD) was diagnosed when glomerular filtration rate (GFR) <60 mL/min/1.73 m² for ≥3 months. The definitions of AKI and CKD were based on the kidney disease improving global outcomes (KDIGO) 2012 criteria.¹⁶

The study data were assembled for further analysis using Research Electronic Data Capture (REDCap)¹⁸ tools hosted at Siriraj Center of Excellence on Bioinformatics and Data Management, Faculty of Medicine, Siriraj Hospital, Mahidol University.

Statistical analysis

Sample size calculation was done according to our pilot study of the oncologic gynecology patients throughout the year 2017. There were 68 cases that were preoperatively reserved for ICU after the end of the operation in our institute. However, only 12 cases were admitted to the ICU postoperatively. Therefore,

the rate of postoperative ICU admission was 12 out of 68 or 0.17. Given the allowable error of 0.05 at the confidence level of 95%, we calculated the sample size of the study based on the formula; $n = [Z_{21-\alpha/2}P(1-P)]/d^2$ and obtained 217 as the approximate number of patients required for the study. With the addition of 10% drop out, the final sample size was 239.

The baseline demographic characteristics of the patients were analyzed and described by mean, percentage, and standard deviation. Two-sided t tests were employed for continuous data when comparing patients with confirmed postoperative ICU admission to those without ICU admission. Mann-Whitney U test was utilized to compare the continuous variables. The multivariable analysis was determined by logistic regression. A p-value of ≤ 0.05 was regarded as statistically significant. The statistical analyses were performed using commercially available SPSS Statistics for Windows, version 21.0 (SPSS Inc., Chicago, Ill., USA).

Results

A total of 400 oncologic gynecology cases from the retrospective reviews were collected. Finally, 321 cases with complete medical record were acquired for further analysis. Of all cases, 62.3% aged less than 65 years old. The average weight, height and BMI of the patients were 61.4 ± 18.0 kg, 154.6 ± 6.0 cm and 25.6 ± 7.0 kg/m², respectively. The majority of the patients were identified having the American Society of Anesthesiologists (ASA) physical status III (71.3%). The leading underlying diseases involved cardiovascular (70.4%), endocrinologic (32.7%)

and respiratory (17.1%) system. Almost 70% of the cases had the diseases of ovarian origin (Table 1). More than half of the patients were reported having hypertension. About one third of the patients have dyslipidemia whereas diabetes accounted for slightly over a quarter of all patients. The patients with respiratory and neurological conditions were the least predominant in this study (Table 1).

Among all 321 cases, there were 90 patients who experienced postoperative ICU admission thus resulting in a rate of 28%. Age, weight, height and body mass index (BMI) were not significantly different between the patients with and without postoperatively admitted to the ICU. Pre- and intra-operative characteristics of the patients were collected and analyzed. The cut off value of each variable was determined by Receiver Operating Characteristic (ROC) curve. The univariate analysis of the pre- and intraoperative characteristics of the patients which showed significant difference between the no ICU and ICU admission groups included 1) preoperative values; platelets $>216,500$ mm³, albumin <3.45 g/dl, prothrombin time (PT) ≥ 12.3 sec, serum glutamic oxaloacetic transaminase (SGOT) ≥ 26.5 U/L and 2) intraoperative events; operative time >290 min, anesthetic time ≥ 360 min, estimated blood loss (EBL) >800 ml, hypotensive time >1 episode and packed red cell (PRC) transfusion >400 ml (P -value <0.05 , Table 3). However, only albumin, PT, SGOT, operative time, anesthesia time, EBL, hypotension and PRC transfusion demonstrated significant association with postoperative ICU admission (Odds ratio (OR) 95% confidence interval (CI) >1 , Table 2). Preoperative ASA status $\geq$ III, presence of

Table 1 Demographic data

Variables	n=321
Age, n (%)	
<65 yr	200 (62.3)
≥65 yr	121 (37.7)
Weight, kg (mean±SD)	61.4±18.0
Height, cm (mean±SD)	154.6±6.0
BMI, kg/m ² (mean±SD)	25.6±7.0
ASA classification, n (%)	
I	2 (0.6)
II	90 (28.0)
III	211 (65.7)
IV	17 (5.3)
V	1 (0.3)
Underlying disease/condition, n (%)	
Cardiovascular	226 (70.4)
Respiratory	55 (17.1)
Endocrine	105 (32.7)
Neurology	30 (9.4)
Urology	47 (14.6)
Sepsis	20 (6.2)
Primary disease, n (%)	
Endometrial	7 (2.2)
Ovarian	220 (68.5)
Cervix	8 (2.5)
Peritoneal	6 (1.9)
Sarcoma	12 (3.7)
Co-existing infection	1 (0.3)
Others, n (%)	3 (0.9)
Recurrence, n (%)	25 (7.8)
Stage of disease, n (%)	
I	54 (16.8)
II	18 (5.6)
III	38 (11.8)
IV	84 (26.2)
Unknown	127 (39.6)

Variables	n=321
Previous abdominal injury, n (%)	115 (35.8)
Preexisting condition, n (%)	176 (54.8)
Hypertension	115 (35.8)
Dyslipidemia	24 (7.5)
Coronary artery disease	3 (0.9)
Cardiomyopathy	26 (8.1)
Arrhythmia	35 (10.9)
DVT	25 (7.8)
Valvular heart disease	11 (3.4)
Pulmonary hypertension	6 (1.9)
Recent heart failure (< 6 months)	10 (3.1)
Other cardiovascular diseases	12 (3.7)
Asthma	1 (0.3)
COPD	18 (5.6)
OSA	20 (6.2)
Pulmonary embolism	5 (1.6)
Other pulmonary diseases	89 (27.7)
Diabetes	18 (5.6)
Thyroid diseases	2 (0.6)
Other endocrine diseases	21 (6.5)
Ischemic/embolic stroke	1 (0.3)
Hemorrhagic stroke	2 (0.6)
Myasthenia gravis	6 (1.9)
Other neurological diseases	8 (2.5)
CKD stages I and II	29 (9.0)
CKD stages III and IV	4 (1.3)
ESRD	5 (1.6)
Other urological diseases	

Table 2 Univariate analysis of the pre- and intraoperative continuous variables associated with ICU admission

Variables	ICU admission		P-value	Odds ratio (95% CI)	ROC cutoff value
	No (n=231)	Yes (n=90)			
Preoperative characteristic/value					
Age (yr)	59.7±15.0	60.6±12.3	0.589	1.89 (0.96, 3.73)	Age ≥50
Weight (kg)	61.9±17.6	60.3±19.1	0.477	1.58 (0.90, 2.78)	Weight ≤47
Height (cm)	154.3±6.3	155.4±5.4	0.125	2.77 (1.13, 6.80)	Height >148
BMI (kg/m ²)	25.9±6.9	24.9±7.5	0.238	2.71 (1.30, 5.63)	BMI ≤18.5
Hct (%)	34.3±4.7	33.9±5.8	0.592	1.89 (0.98, 3.63)	Hct ≤28.6
MCV (%) ^a	83.4±8.6	82.0±7.2	0.132	1.14 (0.69, 1.90)	MCV <79.5
Platelets (/mm ³)	321,705±134,425	377,255±192,244	0.013*	1.22 (0.66, 2.25)	Platelets >216,500
Albumin (g/dl) ^b	3.7±0.5	3.3±0.7	<0.001*	3.06 (1.76, 5.33)	Alb <3.45
PT (sec) ^c	12.9±1.7	13.7±2.6	0.028*	2.51 (1.26, 4.99)	PT ≥12.3
INRd	1.1±0.1	1.2±0.3	0.071	2.19 (0.85, 5.62)	INR ≥1.19
APTT (sec) ^e	27.3±3.9	28.2±4.5	0.182	1.71 (0.88, 3.33)	APTT ≥26.7
APTT ratio ^f	4.1±7.8	15.1±16.8	0.284	n/a	n/a
SGOT (U/L) ^g	24.6±16.7	33.2±29.1	0.027*	3.88 (2.10, 7.18)	SGOT ≥26.5
BUN (mg/dl)	14.7±10.3	13.5±7.8	0.322	2.11 (1.28, 3.47)	BUN <11.2
Cr (mg/dl)	1.0±0.8	0.9±0.5	0.730	2.14 (1.17, 3.90)	Cr <0.6
Intraoperative event					
Op. time (min)	183.3±71.8	213.8±120.8	0.029*	3.53 (1.77, 7.07)	Op. time >290
Anesth. time (min)	235.1±76.7	275.6±124.6	0.005*	4.01 (1.97, 8.18)	Anesth. time ≥360
EBL (ml)	350 (120, 700)	700 (300, 1500)	<0.001*	3.72 (2.19, 6.31)	EBL >800
Hypotension (episode)	1.8±1.9	2.6±2.4	<0.001*	2.52 (1.51, 4.21)	Hypotension >1
PRC transfusion (ml)	464.1±274.3	1,004.0±759.1	<0.001*	5.45 (2.51, 11.83)	PRC >400
Desaturation (min)	2.0±1.4	1.3±0.5	0.588	n/a	n/a

Abbreviations: Anesth., anesthetic; APTT, activated partial thromboplastin time; BMI, body mass index; BUN, blood urea nitrogen; Cr, creatinine; EBL, estimated blood loss; Hct, hematocrit; INR, international normalized ratio; MCV, mean cell volume; n/a, not available; Op., operation; PRC, prothrombin time; ROC, receiver operating characteristic; SGOT, serum glutamic oxaloacetic transaminase; U/L, units per liter; a: total 317 cases; non-ICU admission = 228; ICU admission = 89. b: total 264 cases; non-ICU admission = 188; ICU admission = 76. c: total 167 cases; non-ICU admission = 106; ICU admission = 61. d: total 84 cases; non-ICU admission = 57; ICU admission = 27. e: total 159 cases; non-ICU admission = 102; ICU admission = 57. f: total 16 cases; non-ICU admission = 12; ICU admission = 4. g: total 217 cases; non-ICU admission = 150; ICU admission = 67

Data are expressed as mean±SD, median (P25, P75), or number (%).

*Significance at $P \leq 0.05$.

underlying diseases/conditions such as pulmonary hypertension (PHT), ischemic/embolic stroke and sepsis and intraoperative events/procedures such as hypotension, bradycardia, desaturation, low urine output (<0.5 mL/kg/h), hypothermia, pelvic node lymphadenectomy as well as bowel resection demonstrated significant difference between no ICU and ICU admission groups (Table 3, $P<0.05$). However, only ASA $\geq$ III, PHT, sepsis, hypotension, low urine output, hypothermia and procedures involving bowel resection significantly exhibited association with ICU admission (Table 3, OR 95% CI >1). The multivariate logistic regression model exhibited the statistically significant association with postoperative ICU admission in oncologic gynecology patients which included 1) albumin <3.45 g/dL, 2) EBL >800 mL and 3) low urine output ($P<0.05$ and adjusted OR >1 , Table 4).

Of all 90 cases that required postoperative ICU admission, the major indication was postoperative observation (48.9%). Massive hemorrhage and unstable hemodynamics accounted for 36.7% and 20% of overall postoperative ICU admission causes, respectively (Table 5). The leading postoperative complications of the ICU-admitted patients were acute kidney injury (36.7%) followed by hypotension (32.2%) and pulmonary-related causes (18.9%) (Table 6).

Discussion

Even though the rate of preoperative ICU reservation in gynecologic oncology patients was 60-70 cases/year in our institution, the incidence of actual ICU admission postoperatively

was just below 20 cases/year. Therefore, our study conducted a retrospective analysis of the gynecologic cancer patients who were, ahead of operation time, processed for postoperative ICU reservation by either surgeons or anesthesiologists. In coherent with previous study that the ASA III and ASA IV patients would benefit the most for postoperative critical care¹⁹, over 70% of our study population were classified as ASA $\geq$ III. These patients were preoperatively reserved for the ICU space after the end of operations considering severe preexisting diseases or conditions that might cause adverse outcomes. Anyhow, less than 1/3 of total ICU pre-reserved cases had confirmed for postoperative ICU admission. This could be, in part, because of the unoptimized preoperative patient evaluation. Almost 30% of the preoperative ICU reservation cases were classified as ASA I and II. In this regard, they were unlikely to have worrisome medical conditions thus the need for postoperative ICU admission for this group of patients might not be essential.

According to the fact that admission to the ICU costs significant amount of money, consumes the resource and may not be necessary for every patient, there should be practice guidelines suggesting which case is appropriate for postoperative ICU.^{20,21} Several previous studies on gynecologic oncology patients had introduced the predictors for the requirement of postoperative ICU admission and outcomes regarding prolonged length of ICU stay and mortality.^{1,4,5,22-27} The preoperative aspects that could serve as predictors for postoperative ICU admission included; albumin level <3.5 g/dL, cancer antigen-125 (CA-125) level $>4,125$ U/mL,

Table 3 Univariate analysis of the pre- and intraoperative categorical variables associated with ICU admission

	n (%)	ICU admission		P-value	Odds ratio (95% CI)
		No; n (%)	Yes; n (%)		
Preoperative characteristic					
ASA physical status ≥III	229 (71.3)	154 (66.7)	75 (83.3)	0.003*	2.50 (1.35, 4.64)
Underlying disease/condition					
Cardiovascular	226 (70.4)	165 (71.4)	61 (67.8)	0.520	0.84 (0.50, 1.42)
Hypertension	176 (54.8)	132 (57.1)	44 (48.9)	0.182	0.72 (0.44, 1.17)
Dyslipidemia	115 (35.8)	83 (35.9)	32 (35.6)	0.950	0.98 (0.59, 1.64)
Coronary artery disease	24 (7.5)	19 (8.2)	5 (5.6)	0.414	0.66 (0.24, 1.81)
Cardiomyopathy	3 (0.9)	1 (0.4)	2 (2.2)	0.191	5.23 (0.47, 58.38)
Arrhythmia	26 (8.1)	16 (6.9)	10 (11.1)	0.217	1.68 (0.73, 3.86)
DVT	35 (10.9)	25 (10.8)	10 (11.1)	1.000	1.03 (0.47, 2.24)
Valvular disease	25 (7.8)	15 (6.5)	10 (11.1)	0.248	1.80 (0.78, 4.17)
Recent heart failure	6 (1.9)	3 (1.3)	3 (3.3)	0.355	2.621 (0.52,13.23)
Pulmonary hypertension	11 (3.4)	4 (1.7)	7 (7.8)	0.013*	4.79 (1.37,16.77)
Respiratory					
Asthma	55 (17.1)	37 (16.0)	18 (20.0)	0.395	1.31 (0.70, 2.45)
COPD	12 (3.7)	7 (3.0)	5 (5.6)	0.328	1.88 (0.58, 6.09)
Obstructive sleep apnea	1 (0.3)	1 (0.4)	0	1.000	0.72 (0.67, 0.77)
Pulmonary embolism	18 (5.6)	14 (6.1)	4 (4.4)	0.768	0.72 (0.23, 2.25)
	20 (6.2)	14 (6.1)	6 (6.7)	1.000	1.11 (0.41, 2.98)
Endocrine					
Diabetes mellitus	105 (32.7)	69 (29.9)	36 (40.0)	0.082	1.57 (0.94, 2.60)
Thyroid disease	89 (27.7)	59 (25.5)	30 (33.3)	0.161	1.46 (0.86, 2.47)
	18 (5.6)	12 (5.2)	6 (6.7)	0.807	1.30 (0.47, 3.59)
Neurology					
Ischemic/emboic stroke	30 (9.3)	26 (11.3)	4 (4.4)	0.060	0.37 (0.12, 1.08)
Hemorrhagic stroke	21 (6.5)	20 (8.7)	1 (1.1)	0.027*	0.12 (0.02, 0.90)
Myasthenia Gravis	1 (0.3)	0	1 (1.1)	0.280	0.28 (0.23, 0.33)
	2 (0.6)	2 (0.9)	0	1.000	0.72 (0.67, 0.77)

	n (%)	ICU admission		P-value	Odds ratio (95% CI)
		No; n (%)	Yes; n (%)		
Urology	47 (14.6)	34 (14.7)	13 (14.4)	0.950	0.98 (0.49, 1.95)
CKD I & II	8 (2.5)	6 (2.6)	2 (2.2)	1.000	0.85 (0.17, 4.30)
CKD III & IV	29 (9.0)	21 (9.1)	8 (8.9)	1.000	0.98 (0.42, 2.29)
ESRD	4 (1.2)	3 (1.3)	1 (1.1)	1.000	0.85 (0.09, 8.32)
Sepsis	20 (6.2)	6 (2.6)	14 (15.6)	<0.001*	6.91 (2.56, 18.61)
Ascites	89 (27.7)	63 (27.3)	26 (28.9)	0.771	1.08 (0.63, 1.86)
Pleural effusion	63 (19.6)	42 (18.2)	21 (23.3)	0.297	1.37 (0.76, 2.48)
DVT	30 (9.3)	20 (8.7)	10 (11.1)	0.498	1.32 (0.59, 2.94)
Intraoperative event/procedure					
Hypotension	226 (70.4)	154 (66.7)	72 (80.0)	0.020*	2.00 (1.12, 3.59)
Bradycardia	28 (8.7)	25 (10.8)	3 (3.3)	0.033*	0.28 (0.08, 0.97)
Desaturation	6 (1.9)	2 (0.9)	4 (4.4)	0.033*	5.33 (0.96, 29.60)
Arrhythmia	5 (1.6)	2 (0.9)	3 (3.3)	0.109	3.95 (0.65, 24.03)
Low urine output	36 (11.2)	16 (6.9)	20 (22.2)	<0.001*	3.84 (1.89, 7.81)
Hypothermia	26 (8.1)	13 (5.6)	13 (14.4)	0.010*	2.83 (1.26, 6.37)
Cardiac arrest	1 (0.3)	1 (0.4)	0	0.532	n/a
Debulking surgery	85 (26.5)	57 (24.7)	28 (31.1)	0.240	1.38 (0.80, 2.36)
TAH and/or BSO	253 (78.8)	187 (81.0)	66 (73.3)	0.133	0.65 (0.37, 1.15)
Pelvic node lymphadenectomy	120 (37.4)	99 (42.9)	21 (23.3)	<0.001*	0.41 (0.23, 0.71)
Paraortic node lymphadenectomy	45 (14.0)	37 (16.0)	8 (8.9)	0.098	0.51 (0.23, 1.15)
Omentectomy	170 (53.0)	118 (51.1)	52 (57.8)	0.280	1.31 (0.80, 2.14)
Radical dissection	1 (0.3)	1 (0.4)	0	0.532	n/a
Bowel resection	32 (10.0)	16 (6.9)	16 (17.8)	0.004*	2.91 (1.38, 6.10)

Abbreviations: ASA, American Society of Anesthesiologists; BSO, bilateral salpingo-oophorectomy; CKD I-IV, chronic kidney disease stages I-IV; COPD, chronic obstructive pulmonary disease; ESRD, end-stage renal disease; n/a, not available; TAH, total abdominal hysterectomy; a. Low urine output was designated as < 0.5 ml/kg/h.

*Significance at $P \leq 0.05$.

Table 4 Multivariate analysis of ICU admissions

Variables	P-value	Adjusted odds ratio (95% CI)
Albumin < 3.45 g/dl	0.002*	2.55 (1.42, 4.56)
EBL > 800 ml	< 0.001*	3.39 (1.87, 6.15)
Low urine output	0.018*	2.59 (1.18, 5.68)

Abbreviations: EBL, estimated blood loss; a. total 264 cases; non-ICU admission = 188; ICU admission = 76

*Significance at $P \leq 0.05$.

age ≥ 64 years, CCI < 8 and readmission to the hospital.^{1,26} Our study established the preoperative factors that might be used to predict and affirm postoperative ICU admission. We reported the similar preoperative albumin level (albumin < 3.45 g/dl) to what prior study had described.¹

Previously proposed intraoperative factors were; higher EBL (300-503 ml vs 700-1,630 ml in non-ICU vs ICU, respectively), longer operative time (127.5-211 min vs 150-283 min in non-ICU vs ICU, respectively) and procedures related to intestinal resection.^{4,5,26,27} Here we as well presented that intraoperative EBL > 800 ml was another predictor for ICU admission. However, this EBL cut off value for ICU admission varied from the preceding reports. According to the National Center for Health Statistics (NCHS), Center for Disease Control and Prevention (CDC), the average weight of an adult woman in the USA is 77.5 kg²⁸ whereas the average weight of Thai women is 57.0 kg.²⁹ On this account, the weight-based estimation amount of blood volume is apparently greater in American women who were the participants in the aforementioned studies leading to higher cut off of EBL value (700-1,630 vs 800 ml when compared with our

study). Albeit different study population between previous studies (non-ICU vs ICU patients) and ours (all patients with preoperative ICU reservation), we reported the same parameters (albumin level and EBL) to consider for the postoperative ICU admission. Interestingly, another possible new predictor for postoperative ICU admission postulated in our study could be low intraoperative urine output of < 0.5 ml/kg/h.

In general, the judgement on postoperative ICU admission depends upon the patients' preexisting medical conditions as well as the type and invasiveness of surgery.²⁷ Although Kumar et al. had reported the incidence of obstetric gynecological operations to be 13% of all postoperative ICU admissions, to date, the data regarding the definite proportion of gynecologic oncology patients admitted to the ICU following the operation is limited.³⁰ Proposed indications for postoperative ICU admission were postoperative hemodynamic monitoring and specialized care for the patients with preexisting comorbidities such as respiratory disease, cardiovascular disease, metabolic disorder, neurological disorder and renal impairment.^{31,32} The chief indication for postoperative ICU admission in our study was for postoperative

observation which was coherent with previous reports.^{5,26,31,32}

The limitations of our work could be, firstly, certain preoperative parameters such as mean cell volume (MCV), albumin, prothrombin time (PT), international normalized ratio (INR), activated partial thromboplastin time (APTT), APTT ratio and serum glutamic oxaloacetic transaminase (SGOT) were not collected from all participants according to lack of data (Table 2 and Table 4). Secondly, the indications for ICU admission of some patients were classified as “others” (Table 5). This was because they were not detailed in the medical records. To this end, other possible factors that predisposed to ICU

admission might be overlooked; for example, INR and APTT ratio where only data of 84 and 16 patients were collected and analyzed, respectively (Table 2). Therefore, future study with complete preoperative data is beneficial.

Even so the requirement for postoperative critical care in gynecologic oncology patients is not as high as that of other types of operation³⁰, perioperative patient optimization and vigilant identification of the patients who necessitate the postoperative ICU are paramount. Not only would it reserve the healthcare resource and save the hospital cost, the availability of the ICU beds is also preserved for the patients in need. Our work proposed the possible predictors that could

Table 5 Indications of postoperative ICU admission

Indications	n (%)
Massive hemorrhage	33 (36.7)
Arrhythmia	5 (5.6)
Coronary artery disease	4 (4.4)
Unstable hemodynamics	18 (20.0)
Pulmonary embolism	3 (3.3)
Pulmonary disease	1 (1.1)
Aspiration	1 (1.1)
Hypothermia	3 (3.3)
Postoperative observation	44 (48.9)
Abdominal process (procedure-related injury)	1 (1.1)
Sepsis	14 (15.6)
Bronchospasm/tachypnea	3 (3.3)
Pulmonary edema	2 (2.2)
Residual muscle relaxant	1 (1.1)
Others*	6 (6.7)

Total n = 90

* Patients with preoperative conditions e.g. pulmonary effusion, obstructive sleep apnea with pulmonary hypertension or suspected airway edema

Table 6 Postoperative complications

Complications	n (%)
Prolonged intubation > 72 h	8 (8.9)
Postoperative pulmonary complication	17 (18.9)
Pulmonary embolism	3 (3.3)
Myocardial infarction	3 (3.3)
Congestive heart failure	9 (10.0)
Arrhythmia	6 (6.7)
Hypotension	29 (32.2)
Stroke	5 (5.6)
Acute kidney injury	33 (36.7)
Deep vein thrombosis	2 (2.2)
Surgical complication	10 (11.1)
Cardiac arrest	1 (1.1)
Death	11 (12.2)

Total n = 90

be further implemented in the institutional or national guideline for postoperative ICU admission criteria among known cases with severe preoperative conditions. With proper patient assessment and vigilant intraoperative observation, the rate of overall postoperative ICU cancellations including late cancellations among previously ICU reserved patients are expected to be minimized.

Conclusion

In recent decades, there have been an increasing number of onco-gynecologic patients who have advance stage of disease requiring postoperative ICU admission. Similarly, there are many severe patients undergo other invasive

surgical procedures that need postoperative admission at the critical care unit as well. Unfortunately, there are limited resources not only ICU space itself but also critical care personnel and equipment. These led us to consider in how to use the resources effectively. One way was to find what are associated with postoperative critical care admission to help guide whether we should reserve the ICU space for the patient or not. Ultimately, we postulated factors that aided physicians in clinical decision-making for postoperative ICU admission including preoperative albumin level <3.45 g/dl and intraoperative blood loss >800 ml as well as low urine output <0.5 ml/kg/h. However, these predictors should be taken into consideration with clinical judgement of the clinicians who are involved in perioperative care for the patients.

Acknowledgement

The authors gratefully thank Mr. Suthiphol Udornpuntharak from the Division of Clinical Epidemiology, Department of Research Development, Faculty of Medicine Siriraj Hospital, Mahidol University for his significant help with the statistical analyses and Miss Chayanant Thanakiattiwibun from Integrated Perioperative Geriatric Excellent Research Center, Faculty of Medicine Siriraj Hospital, Mahidol University for her assistance on administrative work and journal submission.

Conflicting interests

The authors declare no conflicts of interest regarding any aspects of this study.

Funding

This research did not receive any specific grants from funding agencies in the public, commercial, or non-profit sectors.

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