Research Square

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Incidence and Outcome of Reintubation in the Postanesthesia Care Unit: a Single-center, Retrospective, Observational Matched Cohort Study in China

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Abstract

Background: Reintubation after planned extubation (RAP) is a serious adverse event. This study aimed to determine the rate and impact of RAP on postoperative course and hospitalization outcomes.

Methods: Of the 121,965 patients in the PACU, 14 patients with RAP were included in this retrospective, single-center, 1:2 matched cohort study in China from January 1, 2017 to December 31, 2019. Duration of PACU stay, postoperative time in the hospital, inpatient healthcare costs, and outcome of hospitalization were compared between the RAP and matched groups.

Results: The rate of RAP occurrence was 0.0115%. After propensity score matching, there were no statistically significant differences in age, sex, body mass index, emergency operation, surgical classification, American Society of Anesthesiologists physical status, and the durations of anesthesia and the procedure between the two groups. Duration of PACU stay, length of postoperative stay, and inpatient healthcare costs significantly differed between the RAP and matched groups ($P < 0.01$ for all). The percentage of patients in whom discharge from the PACU was prolonged was significantly higher in the RAP group than in the matched group (92.86% *vs.*714%), with an odds ratio of 29.87 (95% CI = 14.00 to 2040.54; $P < 0.001$) after matching.

Conclusions: RAP in the PACU had low incidence but was associated with life-threatening and serious complications, increased incidence of prolonged discharge, prolonged PACU and postoperative hospital stay, increased inpatient healthcare costs, and unanticipated intensive care unit admission. Hypoxemia, airway obstruction, dyspnea, respiratory depression, confusion, asthma, chest tightness, pain, hemorrhage, or agitation could be the risk factor for RAP. The appropriate time for tracheal extubation and monitoring in PACU can effectively prevent the occurrence of reintubation and improve the prognosis of patients.

Background

Admission to the postanesthesia care unit (PACU)had been the key for patient recovery after an operation[1]. Adverse respiratory events comprise one of the main critical events in the PACU[2], with a reported incidence rate of 6–55% of all complications[1,3,4]. Reintubation of a surgical patient is a serious adverse respiratory event[5,6]. Based on published literature, the incidence of reintubation after planned extubation(RAP) in the PACU was from 0.0103–0.068%[6–10], with an incidence of 0.069% in China[11].

RAP after surgery was reported to increase the number of unexpected intensive care unit (ICU) admission, length of ICU and hospital stay, duration of full ventilatory support, time to PACU discharge, rates of adverse cardiac events and ventilator-associated pneumonia, morbidity, mortality, cost, and staff demands[5–7, 10,12–16]. RAP is an identifiable event and an outcome marker for quality improvement of post-operative course[17]. In China, RAP has served as a routine anesthesia quality indicator during the perioperative period. Therefore, a very high reintubation rate could represent low quality care and may negatively impact patient outcomes.

In general, immediate extubation in the postoperative period had been the standard and is a safe practice. However, RAP after surgery would be necessary in cases that develop events, such as respiratory failure, hypoxia, hypercapnia, and so on[9]. However, untilnow, detailed information on the outcomes of RAP in the PACU had been scarce. We aimed to determine the rate of RAP and evaluated its impact on duration of PACU and postoperative hospital stays, inpatient healthcare costs, and hospitalization outcomes.

Materials And Methods

The Strengthening the Reporting of Observational Studies in Epidemiology checklist for observational studies was used to guide the methods of this study and the structure of this manuscript. This was a matched cohort study that was conducted using a retrospectively collected database.

The study was carried out in Wuhan City, China at a general public university hospital with 62 clinical departments, 99 surgical rooms, and 38 beds in the PACU. The total number of operations performed in this hospital is more than 90,000/year. The study was approved by the hospital ethics committee and was deemed that written patient consent was not required. The adverse events, including RAP, in all patients in the PACU were recorded on a standardized form in a database by pre-trained qualified nurses and/or anesthesiologists at the time of care from January 1, 2017 to December 31, 2019.

Data, including patient demographic and surgical and anesthesia parameters, were obtained from the anesthesia information system. Adverse events management and duration of PACU stay were also documented. For three years, all collected data were filed in a computer every day and were summarized and analyzed every month. Data, such as demographics, airway, oxygen saturation, consciousness, treatment, vital signs, and fast-track criteria scores, were recorded for all patients in the PACU. The first part contained preoperative and intraoperative data, which were entered into the database by the anesthesiologists involved in the patients' intraoperative care from the time of PACU admission. The second part were recorded by nurse and comprised postoperative data from the PACU to the ward or ICU. The third part were recorded by the surgeons and/ or surgical nurses and comprised postoperative data. The criteria for tracheal extubation in the operating room(OR) and the timing of transfer to the PACU were the responsibility of the anesthesiologist.

RAP was defined as repeat endotracheal intubation in the PACU after planned extubation of the initial endotracheal intubation for general anesthesia or combined general anesthesia other than that performed in the operating room. Patients without RAP during the PACU stay were designated as the matched group, whereas those with RAP during the PACU stay were designated as the RAP group. No RAP cases were missed, because all reintubation procedures were performed in the PACU. Patients on mechanical ventilation before the operation, those who were intubated upon PACU admission after the operation, and those who were admitted directly to a ward or ICU were excluded. The present study had a retrospective, matched cohort design, with a 1:2 match ratio for analysis.

All continuous variables were described as mean (standard deviation) if they followed a normal distribution or as quartiles if they followed a nonnormal distribution. T-test was applied to variables that fit a normal distribution, whereas the nonparametric Mann–Whitney U test was applied to variables that had a nonnormal distribution. Standard Chi-square test was applied to categorical variables, which were depicted as counts or percentages.

In order to have an accurate comparison of the net impact of RAP in the PACU,1:2 propensity score matching (PSM) of the two groups was performed using eight factors. Patients were selected into the RAP or matched group in pairs of comparable characteristics. The matching criteria were set by logistic regression on age, sex, BMI, durations of anesthesia and the procedure, American Society of Anesthesiologists (ASA) physical status, operation procedure, and surgical classification on RAP condition with a caliper. The maximum tolerated difference for matching was set to 0.000001.

Statistical tests were performed using SPSS25 with PSM extension. All reported P values were two-sided, and statistical significance was set at a P value of <0.05 for all reported results.

Results

During the three-year retrospective study period, 121,965 patients underwent procedures under general anesthesia and stayed in the PACU from the OR. As shown in Table 1, there were 14 RAP cases in the PACU; therefore, the incidence of reintubation was 1.15 in 10,000 (0.0115%) anesthesia procedures.

Table 1
Reintubation after planned extubation, incidence and percentages by year

	Patients admitted to PACU(N)	Reintubations (n)	Percent of reintubations(%)
2017	35,447	3	0.0085
2018	40,373	4	0.0099
2019	46,145	7	0.0152
All years	121,965	14	0.0115
Abbreviation: PACU, Postanesthesia Care Unit			

The detailed clinical characteristics of the RAP cases are presented in Table 2. Among the 14 cases of RAP, the type of surgery was urinary in 2 (14.29%), cardiothoracic in 5 (35.71%), bone in 3 (21.43%), ENT in 1 (7.14%), general surgery in 2 (14.29%), and neurosurgery in 1 (7.14%). The main reasons for RAP were atelectasis in 1 (7.14%), respiratory depression in 8 (57.14%), asthma in 2 (14.29%), hemorrhage in 2 (14.29%), hemorrhage and aspiration in 1 (7.14%). The main reasons for respiratory depression were residual neuromuscular blockade in 3 (21.43%), respiratory insufficiency associated with opiums in 6 (42.86%). Nine (64.29%) patients had unplanned transfer to the ICU. The patients were kept intubated after their emergent reintubation for a mean of 2.22 hours (IQR,1.0–13.97hours). Three (21.43%) patients had a pulmonary infection. Five (35.71%) patients were extubated in the PACU. The two (14.29%) patients have died with complications in the ICU, one (7.14%) of which had reoperation. The 11(78.57%) RAP cases were cured. One (7.14%) patient discharged against medical advice. One (7.14%) patient required an emergency surgical airway after reintubation.

Table 2-1

Clinical characteristics with RAP

Patient	Sex	Age (year)	BMI kg/m^2	ASA physical status	Operation procedure	SC	Comorbiditties	Surgical Specialty	Duration of anaesthesia (min)	Duration of procedure (min)	Duration of PACU stay(min
patient 1	male	60	28.55		elective	4	renal cyst	urinary surgery	269	218	64
patient 2	female	28	21.48		elective	2	no	neurosurgery	318	265	90
patient 3	female	60	18.43		elective	4	no	cardiothoracic surgery	191	159	110
patient 4	female	63	32.87		elective	3	diabetes,cerebral infarction	general surgery	195	154	73
patient 5	female	65	24.34		elective	4	asthma	bone surgery	165	110	36
patient 6	female	68	22.67		elective	3	hypertension,diabetes, hyperlipemia,rheumatism	cardiothoracic surgery	235	160	227
patient 7	male	75	24.77		emergency	3	hypertension, tuberculosis	cardiothoracic surgery	125	75	137
patient 8	male	11	16.67		elective	3	no	general surgery	163	95	65
patient 9	male	58	22.86		elective	3	no	bone surgery	177	150	74
patient 10	female	47	23.44		elective	3	hematuria	cardiothoracic surgery	196	130	120
patient 11	female	60	21.64		elective	3	thyroid cancer	cardiothoracic surgery	201	142	66
patient 12	male	64	24.80		emergency	4	no	bone surgery	320	290	100
patient 13	male	65	23.39		elective	3	no	ENT	254	186	140
patient 14	female	64	29.30		elective	4	hypertension	urinary surgery	289	228	151

Abbreviation: RAP, Reintubation after planned extubation; BMI, Body Mass Index; ASA,American Society of Anesthesiologists; SC, Surgical classification; PACU, Postanesthesia care unit

Table 2-2

Clinical characteristics with RAP

Patient	Care unit of postoperative	Oxygenation state after reextubation	Complications	Duration of reintubation (hr)	Postoperative pneumonia	Length of postoperative stay(days)	Discharge outcome
patient 1	ICU	SPO_2>95% with low-flow nasal cannula	no	25.3	yes	12	cure
patient 2	ICU	SPO_2>95% with low-flow nasal cannula	symptom increased	16.5	no	26	discharge against medical advice
patient 3	ICU	SPO_2>95% with low-flow nasal cannula	no	1.0	no	14	cure
patient 4	general ward	SPO_2>95% with low-flow nasal cannula	no	1.0	no	14	cure
patient 5	ICU	SPO_2>95% with low-flow nasal cannula	no	2.0	no	9	cure
patient 6	ICU	90%<SPO_2<94% with high-flow mask	no	21.8	no	22	cure
patient 7	ICU	/	massive hemorrhage and secondary procedures	1.8	no	0	die
patient 8	ICU	60%<SPO_2<90% with invasive ventilation	bleeding in multiple body parts	9.3	yes	1	die
patient 9	general ward	SPO_2>95% with low-flow nasal cannula	no	1.0	no	9	cure
patient 10	general ward	SPO_2>95% with low-flow nasal cannula	no	1.0	no	15	cure
patient 11	ICU	SPO_2>95% with low-flow nasal cannula	no	5.5	no	10	cure
patient 12	ICU	SPO_2>95% with low-flow nasal cannula	no	13.1	no	7	cure
patient 13	OR with intubation	SPO_2>95% with low-flow nasal cannula	tracheotomy	1.1	yes	26	cure
patient 14	general ward	SPO_2>95% with low-flow nasal cannula	no	2.4	no	11	cure

Abbreviation: RAP, Reintubation after planned extubation; ICU, Intensive care unit

As shown in Table 3, the two groups had no significant differences in the demographic factors, such as age, sex, and BMI and in the operation procedure, surgical classification, ASA physical status, and durations of anesthesia and procedure.

Table 3
Baseline date of patients before and after the matching

	No.(%) Without PSM				No.(%) With PSM		
	Total(n=121965)	Nonreintubated (n=121951)	RAP group(n=14)	P	Total(n=42)	Matched group (n=28)	RAP group(n=14)
Gender				0.719			
Female	75383(61.81)	75375(61.81)	8(57.14)		25	17	8(57.14)
Male	46582(38.19)	46576(38.19)	6(42.86)		17	11	6(42.86)
Age (year)	46.00(33.00,56.00)	46.00(33.00,56.00)	61.50(55.25,65.00)	0.002	60.00(49.25,66.50)	56.50(47.75,69.00)	61.50(55.25,65.00
BMI(kg/m^2)	22.77(20.55,25.10)	22.77(20.55,25.10)		0.363	24.19±3.61	24.32±3.36	23.94±4.20
Procedure				0.998			
Elective	100157(82.12)	100145(82.12)	12(85.71)		38(90.48)	26(92.86)	12(85.71)
Emergency	21802(17.88)	21800(17.88)	2(14.29)	0.998	4(9.52)	2(7.14)	2(14.29)
Surgical classification				0.370			
1	4595(3.77)	4595(3.77)	0(0)				
2	24679(20.23)	24678(20.24)	1(7.14)		2(4.76)	1(3.57)	1(7.14)
3	55521(45.52)	55513(45.52)	8(57.14)		21(50.00)	13(46.43)	8(57.14)
4	37170(30.48)	37165(30.48)	5(35.71)		19(45.24)	14(50.00)	5(35.71)
ASA physical status				0.003			
I	41996(34.43)	41996(34.44)	0(0)		2(4.76)	2(7.14)	0(0)
II	71729(58.81)	71719(58.81)	10(71.43)		26(61.90)	16(57.14)	10(71.43)
III	7822(6.41)	7818(6.41)	4(28.57)		14(33.33)	10(35.71)	4(28.57)
□	290(0.24)	290(0.24)	0(0)				
Duration of anaesthesia (min)	140.00 (93.00,205.00)	140.00 (93.00,205.00)	198.50 (174.00,274.00)	0.001	186.50 (135.75,186.50)	165.00 (121.50,268.75)	198.50 (174.00,274.00)
Duration of procedure (min)	105.00 (63.00,165.00)	105.00 (63.00,165.00)	156.50 (125.00,220.50)	0.007	137.50 (93.50,220.50)	117.00 (80.25,237.25)	156.50 (125.00,220.50)

Abbreviation: PSM, Propensity Score Matching; RAP, Reintubation After Planned extubation; BMI, Body Mass Index; ASA, American Society of Anesthesiologists

As shown in Table 4, the RAP and matched groups had significant differences in the duration of PACU stay [95mins(IQR,65.75–137.75mins) *vs.* 29.50mins(IQR,19.25–48.75mins)]; length of postoperative stay [11.50 days(IQR,8.50–16.75days) *vs.* 7.00 days(IQR,5.00–10.75days)]; and inpatient healthcare costs [$10781.58(IQR, $7344.52–15394.24) *vs.*$5506.42(IQR, $3744.12–10486.05)](*P* <0.01 for all). There was no difference between the two groups in terms of the duration of postoperative monitoring [16.96hrs(IQR,8.08–19.75hrs) *vs.* 18.75hrs(IQR,13.46–41.62hrs)].

Table 4
Clinical outcome of patients

	Total(n=42)	Matched group(n=28)	RAP group(n=14)	P
Duration of PACU stay(min)	42.50(22.75,74.75)	29.50(19.25,48.75)	95.00(65.75,137.75)	<0.001
Length of stay(day)	15.00(11.00,23.25)	13.50(9.00,21.75)	20.00(14.50,26.25)	0.067
Length of postoperative stay(day)	8.00(5.00,13.00)	7.00(5.00,10.75)	11.50(8.50,16.75)	0.033
Duration of postoperative monitoring(hr)	17.25(10.58,25.46)	16.96(8.08,19.75)	18.75(13.46,41.62)	0.219
Inpatient healthcare costs($)	7266.21(4589.43,12014.48)	5506.42(3744.12,10486.05)	10781.58(7344.52,15394.24)	0.010
Unanticipated ICU admission	11(26.19)	2(7.14)	9(64.29)	<0.001

Abbreviation: RAP, Reintubation After Planned extubation; PACU, Postanesthesia Care Unit; ICU, Intensive Care Unit

The number of patients in whom discharge from the PACU was prolonged was significantly higher in the RAP group than in the matched group (92.86% *vs.*714%), with an odds ratio after matching of 29.87 (95% CI = 14.00 to 2040.54; P <0.001).

Discussion

RAP in the PACU is a rare occurrence, with reported rates of 0.0103–0.069%[6,7,9–11,17]. Similar to previous reports, our study found a RAP incidence of 0.0115% for three years in the PACU. Unfortunately, we only studied the number of patients who received general anesthesia and did not know the number of patients who were initially intubated. Moreover, we found that the significant consequences of RAP were delayed PACU discharge, increased number of unexpected ICU admissions, longer durations of ICU stay postoperative stay, and increased hospital costs, and staff demands. As previouslyreported[1,18,6], our results showed that RAP had a tendency to prolong hospital stay for three days and had severe implications, including increased morbidity and mortality, too. This retrospective, observational matched cohort study revealed the importance of PACU in the recovery phase of general anesthesia. The staffing and infrastructure of PACU need to be guaranteed, as well as ongoing education and quality assurance standards to ensure that the incidence of RAP can be reduced. In previous studies, reintubation occurred most frequently after airway, cardiac, and thoracic surgeries and after abdominal, neurosurgical, and head and neck procedures in the PACU[5,6]. In our study, the patients with RAP could underwent other operations, such as urinary surgery and bone surgery. The main factors of RAP were general anesthesia and patient's condition, except operative site. In this present study, 4(28.57%) and 10(71.43%) patients with RAP had ASA physical status III and II, respectively. RAP may occur in patients with relatively few comorbidities and in whom clinicians might not expect the occurrence of RAP, as reported previously[8,19].

There were two hospital mortalities with fatal complications in this study. Nevertheless, reintubation remains an important issue because of its significant implications and consequences[14]. Admission to the PACU for RAP after general anesthesia implies life-threatening conditions, serious complications, higher cost, and increased staff demands[6,10,14]. The rate of unplanned transfer to the ICU in our study was higher, compared with the previously reported rate of other adverse events in the PACU[20]. Compared with our study, previous studies[14,21] reported a higher rate (73.3%) of postoperative respiratory complications that necessitated emergency ICU admission. Similar to previous studies[14], our study had a 60% rate of unplanned ICU admission.

Similar to previous reports[9,10], this study found that the risk factors for RAP were hypoxemia, airway obstruction, dyspnea, respiratory depression, confusion, asthma, chest tightness, pain, hemorrhage, and agitation. The median duration of reintubation was shorter in this study than in a previous study about RAP in the ICU[22]. A previous study by Inget al[14] reported that the average duration of reintubation was 2.4 ± 1.9 days (range, 0.5–7 days) in the perioperative period. Early identification and determination of RAP could shorten the duration of reintubation. The appropriate time for tracheal extubation and monitoring in PACU can effectively prevent the occurrence of reintubation and improve the prognosis of patients.

Reducing the probability of reintubation can effectively shorten the time of unnecessary mechanical ventilation and the length of hospital stay[7], thereby, reducing the burden of hospital work and waste of healthcare utilization.

There were a few limitations in this study. Despite our careful attempt to control for confounding factors, residual confounding factors may have been present, because PSM can only balance known confounding factors. Another major limitation of this study was that the date were derived from a self-reporting system.

Conclusions

In conclusion, the incidence of RAP in the PACU was quite low. However, RAP was associated with life-threatening and serious complications, increased the incidence of prolonged discharge and unanticipated ICU admission, prolonged PACU stay and postoperative stay, and increased inpatient healthcare costs and healthcare utilisation. However, the duration of postoperative monitoring remained unchanged. The risk factors for RAP could be hypoxemia, airway obstruction, dyspnea, respiratory depression, confusion, asthma, chest tightness, pain, hemorrhage, or agitation. RAP should be avoided as much as possible to improve the prognosis of patients and save medical resources.

Abbreviations

PACU, Postanesthesia Care Unit; RAP, Reintubation after planned extubation; ICU, Intensive care unit; OR, Operating room; PSM, Propensity Score Matching; BMI, Body Mass Index; ASA, American Society of Anesthesiologists; IQR, interquartile range; SC, Surgical classification

Declarations

Ethics approval and consent to participate

The study was performed in accordance with the ethical standards of the 1964 Declaration of Helsinki. As the study was observational, retrospective, and used existing, routinely collected data, informed consent was not required from the subjects. The study was approved by the Hospital Ethics Committee (TJ-IRB20170501).

Consent for publication

NA

Availability of data and materials

The datasets generated and analyzed in the current study are available from the corresponding author on reasonable request.

Competing interests

The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

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Authors' contributions

Study design: Shangkun Liu and Hong Chen. Data acquisition and analysis: Ying Dong and Shangkun Liu. Data interpretation: Li Wan and Ailin Luo. Manuscript preparation: Shangkun Liu and Hui Xu. Manuscript revision: all authors. Final approval: all authors.

All authors have read and approved the final version of the manuscript.

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