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Timing of pediatric pyloromyotomy on hospital length of stay

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ABSTRACT

Introduction: Pyloromyotomy timing is predicated upon correction of electrolyte abnormalities. Among infants who presented with normal electrolytes, we hypothesized that pyloromyotomy the evening of presentation, rather than waiting until morning, would confer shorter length of stay (LOS).
Methods: This single-center retrospective cohort study included patients who underwent pyloromyotomy from 2012 to 2021. Exposure was time of operation with nighttime considered between the times of 17:00 and 06:59 and daytime between 07:00 and 16:59. A 2:1 daytime to nighttime match was performed among patients who presented with normal electrolytes with Fisher's Exact and Student's *t*-test for comparisons.
Results: Of 520 patients, 15 (3%) underwent pyloromyotomy overnight and were matched to 30 daytime patients. There were no differences in median age (33 days (interquartile range [IQR] 29–44) vs 32 days (IQR 25–44)), male sex (15 (100%) vs 28 (93.3%), or history of prematurity (0 (0%) vs 2 (6.7%)) for nighttime compared to daytime, respectively. Operative outcomes including conversion to open, duodenal perforation, incomplete myotomy, or surgical site infection did not differ between the groups. While the nighttime group had a significantly shorter time from presentation to operating room (OR) than the daytime group (5.3 vs 15.9 h), there were no significant differences in total LOS (45.7 vs 57.3 h, $p = 0.13$).
Conclusion: For infants with hypertrophic pyloric stenosis who present with normal electrolytes, it is safe to offer operation same-day or following a night of hydration. There was no evidence of improved hospital utilization for patients undergoing pyloromyotomy the night of presentation.

Introduction

There is increasing emphasis on cost-effectiveness being a vital component of quality health care, resulting in hospitals working to optimize resource utilization [1,2]. Pyloric stenosis is a common surgical disease in newborns with a reported incidence of 3 out of 1000 births [3]. The widespread adoption of laparoscopic surgery as compared to an open approach has led to decreased costs related to pyloromyotomies, largely due to shorter length of stay (LOS) [4]. Additionally, hospitals have had increasing issues with insufficient bed capacity [5]. Efforts aimed at decreasing LOS may help to increase patient throughput and improve bed capacity, while also lowering costs, which could benefit surgeons, hospitals, and patients [6].

Often, as a result of gastric outlet obstruction and consequent emesis, infants with pyloric stenosis present with dehydration and electrolyte abnormalities that must be corrected before surgery [7]. Non-emergent add-on, operative cases are often scheduled during daytime hours due to more staff availability [8]. Additionally, with decreased staffing at night, there may be patient safety concerns in cases with comorbidities or operative complications [9]. For patients with pyloric stenosis, who present with normalized electrolytes outside of business hours, surgeons face the decision of whether to perform the pyloromyotomy during nighttime hours or postpone surgery until the subsequent day. Our team hypothesized that expediting surgery by taking the patient to the operating room overnight may confer benefits such as shorter LOS. There is an increasing amount of literature describing decreased LOS for non-emergent cases such as laparoscopic cholecystectomy and total hip replacement performed overnight [10,11]. To our knowledge, there are no studies assessing pyloromyotomies performed during nighttime hours as compared to daytime hours and the effect of surgical timing on outcomes.

The aim of this study was to evaluate post-operative outcomes and

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LOS for pyloromyotomies performed at night as compared to during the day. Among infants without electrolyte abnormalities at presentation, we hypothesized that undergoing pyloromyotomy the evening of presentation, rather than waiting until morning, would confer shorter LOS.

Materials and methods

Study population

Our retrospective, single center, cohort study used inclusion criteria of patients 18 years or younger undergoing laparoscopic pyloromyotomy defined by current procedural terminology (CPT) codes 43,520 or 43,659 for pyloric stenosis, or defined by International Classification of Diseases ninth (ICD-9) or tenth (ICD-10) editions codes 750.5 or Q40.0, respectively. Patients who underwent surgery from 2012 to 2021 were included. This study was approved by the Institutional Review Board at Lurie Children's Hospital (IRB# 2022–5128).

Study cohorts

Two cohorts, nighttime and daytime, were defined for comparison. The exposure was time of operation with a nighttime case considered between the times of 17:00 and 06:59 and a daytime case between 07:00 and 16:59. A two to one daytime to nighttime match was performed based on patients who presented with normal electrolytes and within 2 h of time of presentation to the hospital. Normal electrolytes were defined as sodium 136–149 mEq/L, potassium 4.4–6.6 mEq/L, chloride 98–108 mEq/L, bicarbonate 23.0–30.0 mEq/L, and creatinine 0.25–0.54 mEq/L. All cases were laparoscopic pyloromyotomies. All patients had a standardized postoperative feeding regimen, which entailed *ad lib* formula or breast milk feeds. If feeds were not tolerated, graduated increases in volumes every three hours were initiated starting at 30 mL and advancing toward goal.

Demographic, clinical, and outcome variables

Retrospective chart review was performed including sex, age, weight, prematurity status, laboratory values, and pylorus length and width measurements on ultrasound. Primary outcomes of interest were operative complications and LOS. Operative complications included conversion from laparoscopic to open, duodenal perforation, incomplete myotomy, and surgical site infection. Secondary outcomes included time from hospital presentation to operation and discharge.

Statistical analysis

Descriptive statistics were reported as number and percent for categorical variables and median and interquartile range (IQR) for continuous variables. Univariate comparisons between the nighttime and daytime pyloromyotomy groups were performed using Students' t-tests for continuous data and Fischer's exact tests for categorical data. All analyses were conducted using STATA version 17.0 (College Station, TX). The level of significance was set to $p<0.05$.

Results

Demographics

Of the 520 patients who underwent pyloromyotomy during the 9-year study period, only 15 (3%) had surgery during nighttime hours. Those 15 patients were matched 1:2 with a randomly selected cohort of daytime pyloromyotomy patients who also presented with normal electrolytes (Fig. 1). There were no significant differences in median age (33 days (IQR 29–44) vs. 32 days (IQR 25–44), $p = 0.85$), male sex (15 (100%) vs. 28 (93.3%), $p = 0.55$), or history of prematurity (0 (0%) vs. 2 (6.7%), $p = 0.55$) for nighttime compared to daytime cohorts, respectively (Table 1). There were no differences in initial lab values between the nighttime and daytime pyloromyotomy groups including sodium (137.4 vs 137.2 mEq/L, $p = 0.84$), potassium (5.26 vs 5.06 mEq/L, $p = 0.28$), chloride (102.1 vs 100.8 mEq/L, $p = 0.26$), bicarbonate (23.9 vs 24.3 mEq/L, $p = 0.61$), BUN (7.5 vs 7.9 mg/dL, $p = 0.55$), and creatinine (0.25 vs 0.26 mg/dL, $p = 0.21$). Finally, there were no differences in pylorus width (4.7 vs 5.0 mm, $p = 0.35$) or length (1.9 vs 2 cm, $p = 0.21$) between the two groups (Table 2).

Outcomes and length of stay

Comparing the nighttime and daytime pyloromyotomy groups showed no significant differences in operative complications including conversion from laparoscopic to open pyloromyotomy (0% vs. 6.7%, $p = 0.44$), duodenal perforation (0% vs. 3.3%, $p = 0.67$), incomplete myotomy (0% in both cohorts), and surgical site infection (0% in both cohorts) (Table 3). The nighttime pyloromyotomy group had a statistically significant shorter mean time from presentation to operation (5.3

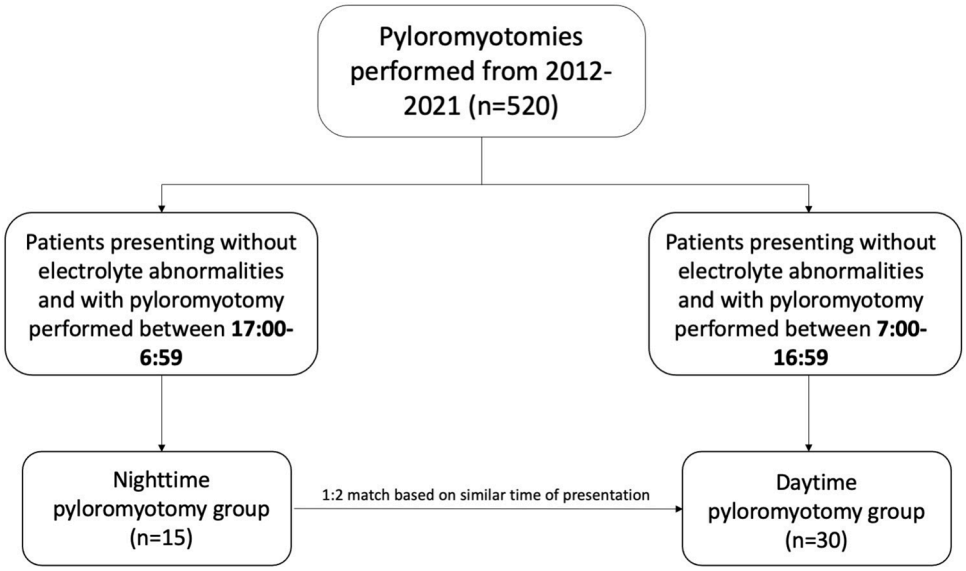

Fig. 1. Consort diagram displaying patient selection.

Table 1
Demographics for patients undergoing pyloromyotomy.

	Nighttime Pyloromyotomy ($n = 15$)	Daytime Pyloromyotomy ($n = 30$)	p-value
Age	33 (29,44)	32 (25,44)	0.85
Sex (male)	15 (100)	28 (93.3)	0.55
History of prematurity	0(0)	2 (6.7)	0.55
Race			0.53
White	5 (33.3)	12 (40)	
Black	0 (0)	1 (3.3)	
Asian	0 (0)	2 (6.7)	
Other	9 (60.0)	0 (0)	
Declined	1 (6.7)	0 (0)	
Ethnicity			1.00
Hispanic	7 (46.7)	14 (46.7)	
Non-Hispanic	8 (53.3)	16 (53.3)	

Data presented as median and interquartile range for age and n (%) for sex, history of prematurity, race, and ethnicity.

Table 2
Initial laboratory values and pyloric measurements for the nighttime and daytime pyloromyotomy groups.

	Nighttime Pyloromyotomy. ($n = 15$)	Daytime Pyloromyotomy ($n = 30$)	p-value
Na (mEq/L)	137.4 (2.5)	137.2 (2.6)	0.84
K (mEq/L)	5.3 (0.6)	5.1 (0.6)	0.29
Cl (mEq/L)	102.1 (4.1)	100.8 (3.1)	0.26
Bicarb (mEq/L)	23.9 (2.6)	24.3 (2.4)	0.61
BUN (mEq/L)	7.5 (2.13)	7.9 (2.3)	0.55
Cr (mEq/L)	0.3 (0.1)	0.3 (0.1)	0.88
Pylorus Width (mm)	4.7 (1.0)	5 (0.7)	0.35
Pylorus Length (cm)	1.9 (0.3)	2 (0.3)	0.21

Data presented as mean and standard deviation.

Table 3
Operative Complications for pyloromyotomy patients.

	Nighttime Pyloromyotomy ($n = 15$)	Daytime Pyloromyotomy ($n = 30$)	p-value
Conversion to open	0 (0)	2 (6.7)	0.44
Duodenal perforation	0 (0)	1 (3.3)	0.67
Incomplete myotomy	0 (0)	0 (0)	
Surgical Site Infection	0 (0)	0 (0)	

Data presented as n (%).

vs 15.9 h, $p<0.01$); however, there was no difference in the mean time from operation to discharge (39.2 vs 40.2 h, $p = 0.89$) between the two groups. Although not statistically significant, the nighttime group had an 11.6-hour shorter total length of stay (45.7 vs 57.3 h, $p = 0.13$) (Fig. 2).

Discussion

In this study, we evaluated LOS and postoperative outcomes in patients presenting with normal electrolytes, who underwent pyloromyotomy at night as compared to during the day. We found that pyloromyotomies performed the night of presentation had an 11.6-hour shorter, although not statistically significant, length of stay with no difference in operative outcomes.

Studies have demonstrated that operative outcomes may be associated with surgical timing. Patients undergoing pediatric neurosurgical operations and plastic surgery free-flaps during nighttime hours have higher complication rates (i.e., re-exploration rates and mortality) compared to cases performed during daytime hours [12,13]. However, patients undergoing appendectomy or hip pinning for fractured hip during nighttime hours were not associated with increased rates of operative complications [14,15]. Our study found that there were no significant differences in the rate of operative complications between patients who underwent pyloromyotomy during nighttime hours versus those who underwent the procedure during daytime hours. Additionally, the low complication rate observed in the nighttime group is consistent with the currently reported rates of complications for patients who undergo laparoscopic pyloromyotomy [16], suggesting that pyloromyotomy is a safe procedure with a low risk of complications, regardless of surgical timing.

Although pyloromyotomy may be performed safely at night, the existing literature does not provide strong evidence of any clear advantage, such as decreased LOS, of performing the procedure during non-business hours. For patients undergoing laparoscopic cholecystectomy, Tseng *et al.* found that those who had surgery overnight had a shorter pre-operative LOS but no difference in post-operative LOS. These findings led to an overall shorter total LOS for the patients who had surgery at night, by 1 day, when compared to those who had surgery during the day [17]. Similarly, we found that patients in the nighttime pyloromyotomy group had a shorter time from presentation to operation and no difference in time from operation to discharge. However, this did not lead to a statistically shorter total LOS despite the nighttime group LOS being 11.6 h briefer in comparison to the daytime group. One explanation for the timing from operation to discharge being similar in the two groups is that patients who had nighttime surgery were likely sleeping overnight postoperatively, so their feeding trials may not have started until the next morning. Additionally, other confounding factors that are difficult to measure, such as patient and family transportation issues, patients being ready for discharge at an inconvenient time (i.e., middle of the night), nurse staffing, and team rounding times may have contributed.

Though performing pyloromyotomies at night is safe, we did not find evidence of improved hospital utilization. Recently, there has been an increasing number of academic hospitals with 24-hour in-house availability of anesthesia providers and pediatric surgeons [18,19]. Factors that may justify performing pyloromyotomy during nighttime hours for a patient with normalized electrolytes include availability of providers, lower workload during nighttime hours, and a fully booked surgical schedule for the upcoming day. Offloading cases such as pyloromyotomy to nighttime hours may improve workflow for the daytime teams, but these scenarios are not common occurrences. Competing forces such as surgeon well-being, availability of sufficient operating room staff and resource deployment for non-emergent cases must be considered.

This study is not without limitations. First, the retrospective cohort design, restricted to a single center, produced a limited sample size. Over the 9-year study period, only 15 patients underwent surgical intervention at night, which could be too small of a sample size to detect a meaningful difference. Second, it is important to recognize that the definition of nighttime surgery may differ based on institution and therefore may not be widely generalizable. Additionally, this may not be generalizable to hospitals without in-house pediatric surgeons or anesthesia providers. Third, there are many confounders that may influence LOS that are difficult to measure in a retrospective review, though we do have a standardized postoperative feeding regimen. Finally, we were unable to assess surgeon comfort with operating overnight or the different resources available to them, which also may influence decisions related to timing of surgical intervention.

Conclusions

Performing pyloromyotomy the night of presentation for patients

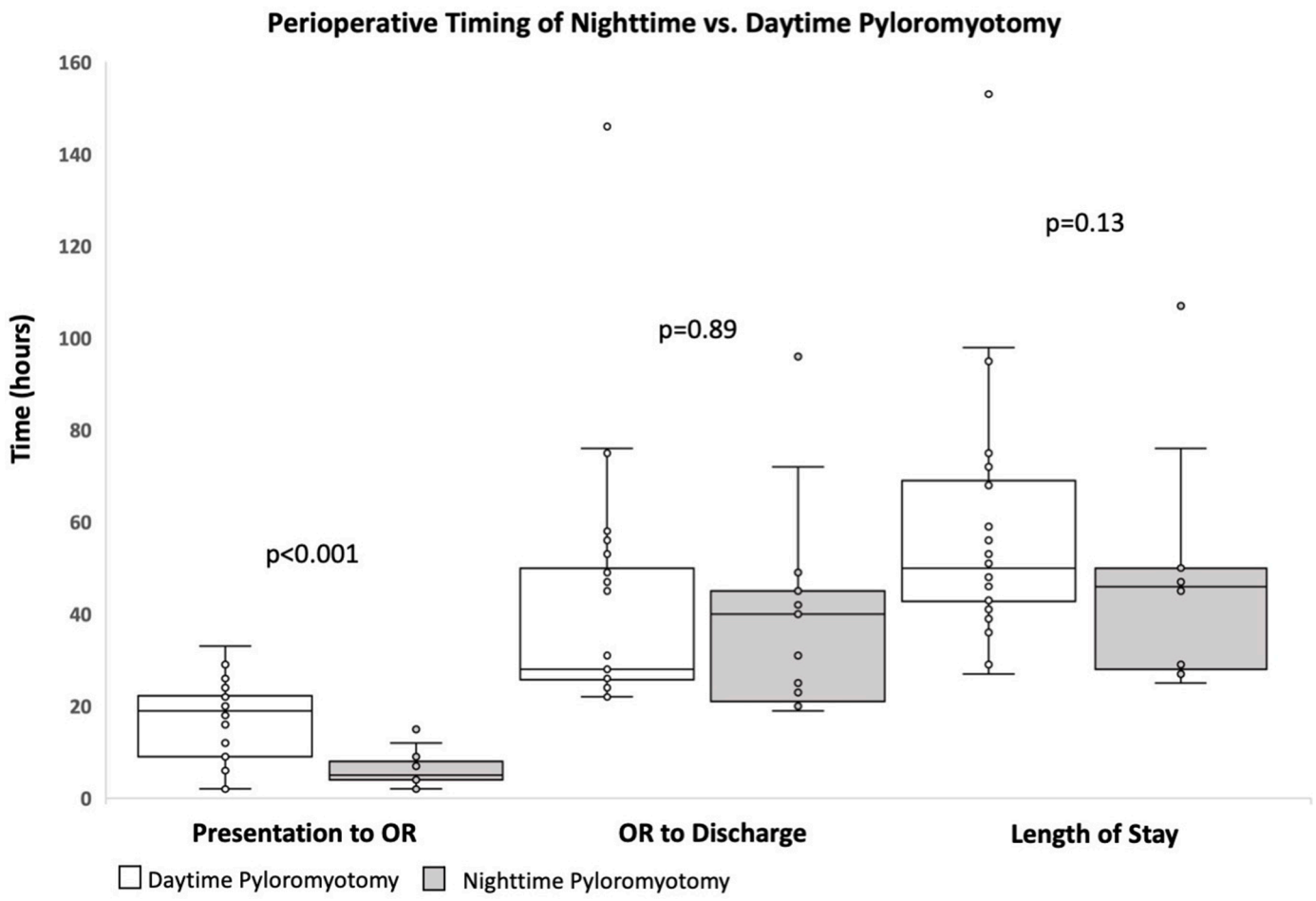

Fig. 2. Perioperative Timing of Nighttime vs. Daytime Pyloromyotomy.

who present with normal electrolytes appears to be safe with equivalent postoperative outcomes, however there is no improvement in hospital utilization.

Author contributions

Authors FNL, AJR, and MVR completed the conceptualization, formal analysis, drafting, approval, and accountability. Authors SP, GZ, SDG, CS, and TBL contributed to critical review, approval, and accountability.

Disclosures

The authors report no proprietary or commercial interest in any product mentioned or concept discussed in this article.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.sipas.2023.100177.

References

[1] Lee SJ, Calderon B, Gardner GJ, Mays A, Nolan S, Sonoda Y, Barakat RR, Leitao Jr MM. The feasibility and safety of same-day discharge after robotic-assisted hysterectomy alone or with other procedures for benign and malignant indications. Gynecol Oncol 2014;133(3):552–5. https://doi.org/10.1016/j.ygyno.2014.04.006 From NLM.

[2] Mayo BC, Massel DH, Bohl DD, Long WW, Modi KD, Singh K. Effect of surgery start time on day of discharge in anterior cervical discectomy and fusion patients. Spine 2016;41(24):1939–44. https://doi.org/10.1097/brs.0000000000001627 From NLM (Phila Pa 1976).

[3] Stark CM, Rogers PL, Eberly MD, Nylund CM. Association of prematurity with the development of infantile hypertrophic pyloric stenosis. Pediatr Res 2015;78(2):218–22. https://doi.org/10.1038/pr.2015.92 From NLM.

[4] Kethman WC, Harris AHS, Hawn MT, Wall JK. Trends and surgical outcomes of laparoscopic versus open pyloromyotomy. Surg Endosc 2018;32(7):3380–5. https://doi.org/10.1007/s00464-018-6060-0 From NLM.

[5] Scott IA. Public hospital bed crisis: too few or too misused? Aust Health Rev 2010;34(3):317–24. https://doi.org/10.1071/ah09821 From NLM.

[6] Carrington EV, Hall NJ, Pacilli M, Drake DP, Curry JI, Kiely EM, De Coppi P, Pierro A, Eaton S. Cost-effectiveness of laparoscopic versus open pyloromyotomy. J Surg Res 2012;178(1):315–20. https://doi.org/10.1016/j.jss.2012.01.031 From NLM.

[7] Nakayama DK. Hypertrophic pyloric stenosis in infancy. An analysis of treatment outcome. N C Med J 1998;59(5):310–3. From NLM.

[8] Wright JG, Roche A, Khoury AE. Improving on-time surgical starts in an operating room. Can J Surg 2010;53(3):167–70. From NLM.

[9] Turrentine FE, Wang H, Young JS, Calland JF. What is the safety of nonemergent operative procedures performed at night? A study of 10,426 operations at an academic tertiary care hospital using the American College of Surgeons national

surgical quality program improvement database. J Trauma 2010;69(2):313–9. https://doi.org/10.1097/TA.0b013e3181e49291 From NLM.
[10] Fernandes S, Carvalho AF, Rodrigues AJ, Costa P, Sanz M, Goulart A, Rios H, Leão P. Day and night surgery: is there any influence in the patient postoperative period of urgent colorectal intervention? Int J Colorectal Dis 2016;31(3):525–33. https://doi.org/10.1007/s00384-015-2494-1 From NLM.
[11] Qurashi S, Chinnappa J, Aktas S, Dabboussi AM, Rahman MB. Overnight joint replacement surgery: a pilot Australian study. ANZ J Surg 2022;92(10):2683–7. https://doi.org/10.1111/ans.17977 From NLM.
[12] Desai V, Gonda D, Ryan SL, Briceño V, Lam SK, Luerssen TG, Syed SH, Jea A. The effect of weekend and after-hours surgery on morbidity and mortality rates in pediatric neurosurgery patients. J Neurosurg Pediatr 2015;16(6):726–31. https://doi.org/10.3171/2015.6.peds15184 From NLM.
[13] Lee KT, Mun GH. Is after-hours free-flap surgery associated with adverse outcomes? J Plast Reconstr Aesthet Surg 2013;66(4):460–6. https://doi.org/10.1016/j.bjps.2012.12.007 From NLM.
[14] Pincus D, Desai SJ, Wasserstein D, Ravi B, Paterson JM, Henry P, Kreder HJ, Jenkinson R. Outcomes of after-hours hip fracture surgery. J Bone Joint Surg Am 2017;99(11):914–22. https://doi.org/10.2106/jbjs.16.00788 From NLM.
[15] Mönttinen T, Kangaspunta H, Laukkarinen J, Ukkonen M. Nighttime appendectomy is safe and has similar outcomes as daytime appendectomy: a study of 1198 appendectomies. Scand J Surg 2021;110(2):227–32. https://doi.org/10.1177/1457496920938605 From NLM.
[16] van den Bunder F, van Heurn E, Derikx JPM. Comparison of laparoscopic and open pyloromyotomy: concerns for omental herniation at port sites after the laparoscopic approach. Sci Rep 2020;10(1):363. https://doi.org/10.1038/s41598-019-57031-4 From NLM.
[17] Tseng ES, Imran JB, Nassour I, Luk SS, Cripps MW. Laparoscopic cholecystectomy is safe both day and night. J Surg Res 2019;233:163–6. https://doi.org/10.1016/j.jss.2018.07.071 From NLM.
[18] St Peter SD, Calkins CM, Holcomb 3rd GW, Snyder CL, Ostlie DJ. Financial impact of in-house attending surgeon: a prospective study. J Pediatr Surg 2008;43(6):994–7. https://doi.org/10.1016/j.jpedsurg.2008.02.017 From NLM.
[19] Wong LR, Flynn-Evans E, Ruskin KJ. Fatigue risk management: the impact of anesthesiology residents' work schedules on job performance and a review of potential countermeasures. Anesth Analg 2018;126(4):1340–8. https://doi.org/10.1213/ane.0000000000002548 From NLM.