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Surgeons, attention to infernal cycles

October 21, 2009 - Vincent Bargoin (theheart.org)

Boston, United States - a surgeon running through surgical operations one after the other without a sufficient time of recovery represents a priori a risk to the patients. A study published in *the Newspaper of the American Medical Association*, confirms the need for a rest of at least 6 hours between a night intervention and an intervention during the day which follows. [1]

Rothschild JM, Keohane CA, Rogers S et col. Risks of complications by attending physicians after performing nighttime procedures. *JAMA* 2009 ; 302(14) : 1565-72.

The study retrospectively evaluates 919 surgical operations of all types, and 957 childbirth carried out at daytime, by 86 surgeons or 134 obstetricians already solicited for an intervention during the night. The complications, which have occurred during these interventions, were reported to the complications, which have occurred at the time of 3552 surgical procedures and 3945 obstetrical control procedures. These control procedures were realized by the same surgeons or obstetricians as the evaluated procedures, but had not been preceded by night interventions.

One notes by the way that the surgeons and obstetricians participating in the study did not have a statute of "resident", but of "fellow" in their respective medical centres. The nuance is significant in the United States where, since 2003, the working time of the residents is limited (30 working hours consecutive, and 80 hours per week), but not the working time of the fellows. It is besides obviously that it is to raise this problem that the study was undertaken.

On the whole, the complications do not appear significantly more frequent for the interventions carried out consecutive with a night intervention (5,4% of complications), only for the controls interventions (4,9%). The time of recovery has nevertheless a significant impact,

since the rate of complications of the interventions carried out after less than 6 hours of recovery, exceeds the rate noted after a sufficient recovery (6,2% vs 3,4%; p=0,04). This variation is in addition more significant for the surgical procedures (8,5% vs 3,1%; p=0,03).

Lastly, without being statistically significant, a tendency is at least demonstrative. When more than 12 hours ran out between the beginning of the procedure of night, and the end of the last procedure of day, the rate of complications is 6,5%, against 4,3% for shorter times (p=0,08).

As a whole, "these data suggest that the fellows doctors, as well as the residents and the nurses, could have more risks to make errors after a deprivation of sleep, or when they work for too long time", the authors underline.

The article of the JAMA also raises that in his report of 2008, the **Institute of Medicine of the National Research Council** does not make any comment on the question of the working time of the fellows. For as much, the authors do not preach - in all cases not explicitly - a legislative framing. They are restricted to recommend "a culture of team work ", "adequate designs of the timetables", "better practices of sleep", and "a suitable use of caffeine"…

Original in French, translation by Systran® translation software.

Article JAMA here attached

ORIGINAL CONTRIBUTION

Risks of Complications by Attending Physicians After Performing Nighttime Procedures

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Context Few data exist on the relationships between experienced physicians' work hours and sleep, and patient safety.

Objective To determine if sleep opportunities for attending surgeons and obstetricians/gynecologists are associated with the risk of complications.

Design, Setting, and Patients Matched retrospective cohort study of procedures performed from January 1999 through June 2008 by attending physicians (86 surgeons and 134 obstetricians/gynecologists) who had been in the hospital performing another procedure involving adult patients for at least part of the preceding night (12 AM-6 AM, postnighttime procedures). Sleep opportunity was calculated as the time between end of the overnight procedure and start of the first procedure the following day. Matched control procedures included as many as 5 procedures of the same type performed by the same physician on days without preceding overnight procedures. Complications were identified and classified by a blinded 3-step process that included administrative screening, medical record reviews, and clinician ratings.

Main Outcome Measures Rates of complications in postnighttime procedures as compared with controls; rates of complications in postnighttime procedures among physicians with more than 6-hour sleep opportunities vs those with sleep opportunities of 6 hours or less.

Results A total of 919 surgical and 957 obstetrical postnighttime procedures were matched with 3552 and 3945 control procedures, respectively. Complications occurred in 101 postnighttime procedures (5.4%) and 365 control procedures (4.9%) (odds ratio, 1.09; 95% confidence interval [CI], 0.84-1.41). Complications occurred in 82 of 1317 postnighttime procedures with sleep opportunities of 6 hours or less (6.2%) vs 19 of 559 postnighttime procedures with sleep opportunities of more than 6 hours (3.4%) (odds ratio, 1.72; 95% CI, 1.02-2.89). Postnighttime procedures completed after working more than than 12 hours (n=958) compared with 12 hours or less (n=918) had nonsignificantly higher complication rates (6.5% vs 4.3%; odds ratio, 1.47; 95% CI, 0.96-2.27).

Conclusion Overall, procedures performed the day after attending physicians worked overnight were not associated with significantly increased complication rates, although there was an increased rate of complications among postnighttime surgical procedures performed by physicians with sleep opportunities of less than 6 hours.

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INCREASING PUBLIC ATTENTION HAS been focused on the role of resident physicians' fatigue in the occurrence of medical errors, including percutaneous needlestick and laceration injuries and postcall motor vehicle crashes.[1-3] Less is known about the effects of extended-duration work shifts on the performance of attending physicians. Attending physicians who perform emergency operations or perform deliveries during the night often schedule elective procedures or deliveries the following day. It is possible that experienced attending physicians may be better able to cope with the effects of sleep deprivation than residents. Furthermore, the surgical environment differs sufficiently from other medical environments so findings from medical settings may not be directly applicable.[4] To date, little research either supports or refutes these hypotheses.[5]

In 2003, the Accreditation Council for Graduate Medical Education implemented resident physicians work hour limits of 30 consecutive work hours and 80 weekly hours.[6] Unlike residents, the work hours of attending physicians in the United States are not restricted. Little is known about the frequency of elective surgical and obstetrical/gynecologic (ob-gyn) procedures by attending physicians who participate in emergency procedures the night before. Even less is known about the risks of complications during these postnighttime procedures. We therefore conducted a study to address these gaps in knowledge.

METHODS

The study hospital was a 745-bed urban, tertiary care academic trauma center and referral center for high-risk obstetrical procedures. Procedures conducted in either the operating room or labor and delivery suite (L/D) between January 2000 and December 2007 were eligible for matching

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with control procedures of the same type that were completed between January 1999 and June 2008. Most surgical procedures included a resident physician or other assistant. The human research committee approved the study.

Overall Study Design

We conducted a matched retrospective cohort study in which we identified all attending surgeons and obstetricians/gynecologists who were involved in overnight and early morning emergency operating room and L/D procedures prior to a daytime procedure. We matched these daytime procedures (postnighttime procedures) that followed overnight emergency procedures performed by the same attending physician at some point between midnight and 6 AM (overnight index procedures) with daytime procedures (control procedures) that did not follow overnight procedures. Each postnighttime procedure was matched by physician with as many as 5 of his or her most contemporaneous control procedures of the same or similar type. Postnighttime procedures without at least 1 matched control were excluded from analysis. Because of the lower complication rate in spontaneous vaginal deliveries,[7] we enriched the daytime case sampling with cesarean deliveries.

Table 1. Patient Demographics

	No. (%) of Procedures		
	Postnighttime (n = 919)	Control (n = 3552)	*P* Value
Operating Room			
Female sex	690 (75.1)	2548 (71.7)	.20
Age, mean (SD), y	49.1 (16.3)	50.0 (16.3)	.94
Charlson score			
0	585 (63.7)	2159 (60.8)	.25
1	108 (11.8)	399 (11.2)	
2	93 (10.1)	445 (12.5)	
3	44 (4.8)	188 (5.3)	
4	21 (2.3)	66 (1.9)	
5	9 (1.0)	25 (0.7)	
>5	59 (6.4)	270 (7.6)	
Comorbidities			
Cancer	135 (14.7)	568 (16.0)	.64
Chronic pulmonary disease	96 (10.4)	362 (10.2)	.78
Congestive heart failure	70 (7.6)	266 (7.5)	.57
Diabetes	83 (9.0)	403 (11.3)	.08
Liver disease	7 (0.8)	15 (0.4)	.20
Myocardial infarction	43 (4.7)	217 (6.1)	.19
Renal disease	14 (1.5)	71 (2.0)	.44
Labor and Delivery	Postnighttime (n = 957)	Control (n = 3945)	
Female sex	957 (100.0)	3945 (100)	
Age, mean (SD), y	32.9 (5.2)	33.5 (5.0)	.001
Charlson score			
0	892 (93.2)	3684 (93.4)	.99
1	59 (6.2)	238 (6.0)	
2	2 (0.2)	12 (0.3)	
3	1 (0.1)	4 (0.1)	
4	1 (0.1)	0	
5	0	0	
>5	2 (0.2)	7 (0.2)	
Comorbidities			
Cancer	3 (0.3)	9 (0.2)	.63
Chronic pulmonary disease	47 (4.9)	179 (4.5)	.62
Congestive heart failure	2 (0.2)	4 (0.1)	.40
Diabetes	9 (0.9)	48 (1.2)	.50
Liver disease	1 (0.1)	0	
Myocardial infarction	0	0	
Renal disease	0	1 (0.0)	

Abbreviation: SD, standard deviation.

Outcomes and Predictors of Interest

The primary outcomes were the presence of surgical and ob-gyn procedural complications, defined as adverse events occurring as a result of care during an operation or delivery and likely attributable to the performance of the attending surgeon or obstetrician/gynecologist. Preventable complications were complications judged to have likely been due to a surgical error. We excluded the following: adverse outcomes likely due to the patient's condition (eg, septic shock during repair of infarcted bowel); adverse events judged unlikely to be associated with the attending surgeon or obstetrician/gynecologist (eg, anesthetic-induced hypotension); and adverse events of unclear relationship to intraoperative care (eg, pulmonary embolus).

Surgical complications included infection, massive hemorrhage, organ injury, wound failure, and other complications such as failed procedures. Additional obstetrical/peripartum complications included greater than 1000-mL blood loss, stillbirth, umbilical cord prolapse, shoulder dystocia, birth trauma, and fourth-degree perineal tear.[8,9]

Start and end times (procedure duration) were the time of initial skin incision to surgery end, and for vaginal deliveries were the beginning of the second stage of labor to the end of the third stage. Procedure duration did not include estimates of time spent with the patient preoperatively and postoperatively.

We assessed 2 additional predictors of fatigue in postnighttime procedures.[10] Sleep opportunity was defined as the time period between the end of the last overnight index procedure and the beginning of the first daytime postnighttime procedure. For analysis, we dichotomized sleep opportunity to 0 to 6 hours vs greater than 6 hours. The work duration for each post-

nighttime procedure was the time from the start of the first overnight index procedure to the end of each postnighttime procedure. Consecutive postnighttime procedures accrued unique and increasingly longer work durations. For analysis, work duration was dichotomized into a 0- to 12-hour category vs a greater than 12-hour one.

Physician age, experience as measured by postgraduate years, sex, and specialty were collected, as were patient age, sex, primary diagnosis, comorbidities, Charlson score, and discharge disposition. Procedure data included outpatient or inpatient status, location of procedure in the operating room or L/D, number of procedures performed by the attending physician, and type of procedure by organ system.

Table 2. Physician Demographics

	All Staff[a]	Study Only[b]	*P* Value
No. of surgeons	492	86	
Female sex	94 (19.1)	14 (16.3)	.55
Age, mean (SD), y[c]	42.2 (9.0)	42.0 (7.6)	.62
Length of experience, mean (SD), y[c]	13.7 (10.1)	14.0 (8.9)	.38
No. of obstetricians/gynecologists	331	134	
Female sex	238 (71.9)	96 (71.6)	.90
Age, mean (SD), y[c]	41.6 (11.0)	42.0 (9.0)	.19
Length of experience, mean (SD), y[c]	11.1 (11.7)	14.7 (9.4)	<.001
Surgical specialty			
Cardiac	25 (5.1)	7 (8.1)	<.001
General	122 (24.8)	32 (37.2)	
Neurosurgery	29 (5.9)	8 (9.3)	
Orthopedic	142 (28.9)	17 (19.8)	
Thoracic	15 (3.0)	4 (4.7)	
Vascular	9 (1.8)	3 (3.5)	
Other	146 (29.7)	15 (17.4)	

Abbreviation: SD, standard deviation.
[a] Includes all staff attending surgeons and obstetricians/gynecologists who performed at least 1 procedure at any time between January 2000 and December 2007.
[b] Includes study surgeons and obstetricians/gynecologists who performed at least 1 postnighttime procedure with matched control procedures.
[c] Age and years of experience were calculated for each physician. The years of experience variable was calculated as the number of postgraduate years plus years of training (residency and fellowship). For the entire staff, the age and years of experience variables for each physician were calculated as the mean age and mean years of experience during the years on staff between 2000 and 2007. For the study physicians, the age and years of experience variables for each physician were calculated as the age and years of experience at the time of a postnighttime procedure. For physicians with multiple postnighttime procedures in different years, we used the mean age and mean years of experience for those calendar years in which the procedures were performed.

Procedure Matching

We matched postnighttime procedures with same or similar controls by the same attending physician within 12 months for surgical procedures and within 6 months for ob-gyn procedures. We matched as many as 5 controls for each postnighttime procedure preferentially using the same *International Classification of Diseases, Ninth Revision* (*ICD-9*) procedure code, and if necessary, allowed matches of 1 higher coding level (ie, of slightly lesser specificity). Potential control procedures were excluded from matching if they occurred on the same day or 1 day after any postnighttime case. Control cases could be used only once for matching.

Complication Screening and Evaluation

We electronically screened for complications using *ICD-9-Clinical Modification* (*CM*) periprocedural surgical and ob-gyn complications codes in the Agency for Healthcare Research and Quality Guide to Patient Safety Indicators[11] and the Complications Screening Program.[12] We also used a previously validated set of administrative adverse event screens including 30-day readmissions.[13] We created data warehouse queries using the Obstetrics Adverse Outcome Index[14] to capture additional obstetrical complications including transfusion during delivery.

Following administrative screening, we used a 2-tiered approach for identifying procedural complications.[15] Administrative screen-positive procedures underwent medical record review by 2 trained data abstractors. Interrater reliability testing was conducted prior to data collection. Abstracted cases with suspected complications were independently evaluated by clinician pairs with experience in rating complications. Complications were judged on the likelihood of preventability and severity of injury using a previously developed rating system.[16] Disagreements were resolved by consensus. Chart abstractors and clinician reviewers were blinded to whether incidents occurred during postnighttime or matched control procedures, overnight sleep opportunities, and shift durations.

Statistical Analysis

In analyses relating procedure type (postnighttime or control) with other variables, generalized linear mixed models were used to account for the clustering of patients within attending physicians and within matched sets.[17,18] We reported means and proportions of the baseline characteristics and used generalized linear mixed models and Wald *P* values for differences between postnighttime and control procedures. We initially compared differences in outcomes using generalized linear mixed models odds ratios (ORs), *P* values, and 95% confidence intervals (CIs) without adjusting for any confounders (but accounting for clustering), and then used generalized linear mixed models to compute multivariable-adjusted ORs between outcomes and procedure type and 95% CIs. We also conducted analyses comparing complication rates of postnighttime procedures in which attending physicians had 0 to 6 hours of sleep vs greater than 6-hour sleep opportunities and work duration was 0 to 12 hours vs greater than 12 hours.

A priori confounders included age, comorbidities, and sex for operating room procedures. Clustering is incorporated

in generalized linear mixed models such that we did not need to adjust for matching factors. Any covariate was kept in a multivariable model if it led to a 10% change in the OR estimate between outcome and procedure type.

For complication ratings among reviewers, the *k* coefficient was used to assess interrater reliability. All analyses were conducted using Proc Glimmix or Proc Freq in SAS version 9.2, (SAS Institute Inc, Cary, North Carolina). All tests were 2-tailed, and a *P* value of less then .05 was considered significant. Since testing for the association of complications with procedure type, sleep opportunity, and work duration were planned a priori, we have not adjusted the type 1 error to account for multiple comparisons; thus, the *P* values should be interpreted cautiously.

This study had 80% power ($\alpha = 5\%$) to detect a decrease in the complication rate from 4% in postnighttime procedures to 2.65% in control procedures using the generalized linear mixed models Wald test. With the observed complication rate of 5.4% in postnighttime procedures, we had 80% power to detect a decrease to 3.8%.

Table 3. Procedure Types and Frequency per Physician and by Specialty

	No. (%) of Procedures	
	Postnighttime	Control
Labor and delivery procedure	(n = 957)	(n = 3945)
Cesarean delivery	880 (92.0)	3867 (98.0)
Repair of obstetric laceration	53 (5.5)	52 (1.3)
Spontaneous vaginal delivery	20 (2.1)	21 (0.5)
Vacuum or forceps-assisted delivery	4 (0.4)	5 (0.1)
Operating room procedure by schedule	(n = 919)	(n = 3552)
Elective, previously scheduled	678 (73.8)	2830 (79.7)
Outpatient	426 (46.4)	1567 (44.1)
Emergency	138 (15)	392 (11)
Elective, add-on same day	103 (11.2)	330 (9.3)
Operating room procedure by type		
Female genital organs	419 (45.6)	1443 (43.0)
Other incision/excision of uterus	211 (23.0)	812 (24.2)
Other uterus and supporting structures	72 (7.8)	226 (6.7)
Ovary	47 (5.1)	136 (4.1)
Fallopian tubes	39 (4.2)	112 (3.3)
Cervix	32 (3.5)	112 (3.3)
Other genital organ	18 (2.0)	45 (1.3)
Digestive system	205 (22.3)	832 (24.8)
Stomach	20 (2.2)	87 (2.6)
Intestine incision/excision and anastomosis	29 (3.2)	124 (3.7)
Gallbladder and biliary tree	46 (5.0)	211 (6.3)
Hernia repair	30 (3.3)	139 (4.1)
Other	80 (8.7)	271 (8.1)
Cardiovascular system	93 (10.1)	424 (12.7)
Valve	24 (2.6)	119 (3.6)
Coronary artery	39 (4.2)	180 (5.4)
Other	30 (3.3)	125 (3.8)
Musculoskeletal system	53 (5.8)	208 (6.2)
Skin/subcutaneous (includes implantable vascular access)	52 (5.7)	241 (7.2)
Central nervous system	28 (3.0)	116 (3.5)
Respiratory system	26 (2.8)	104 (3.1)
Other	20 (2.2)	72 (2.1)
Urinary system	14 (1.5)	67 (2.0)
Breast	9 (1.0)	45 (1.3)
Procedures per physician by specialty		
Surgeons (n = 86)		
Mean (median) [range]	6.1 (4) [1-39]	25.9 (15) [1-181]
Obstetricians/gynecologists (n = 134)		
Mean (median) [range]	10.1 (4) [1-104]	39.3 (15) [1-415]

Abbreviation: SD, standard deviation.

RESULTS

Procedure and Physician Characteristics

A total of 217 953 operating room and 69 509 L/D procedures were performed during the study period. We identified 4059 operating room index procedures (1.9%) and 17 886 L/D ones (25.7%) that ended or started between 12 AM and 6 AM (eFigure, available at http://www.jama.com). There were 1135 operating room and 2945 L/D procedures performed by the same physician on the same day as the index procedure. We were able to match 919 postnighttime operating room procedures (81%) and 957 postnighttime L/D procedures (32.5%) to at least 1 control. We matched an average of 3.9 operating room control procedures with each postnighttime one (n = 3552) and 4.1 L/D control procedures with each postnighttime one (n = 3945). There were no differences between patients who underwent control and postnighttime procedures except that control ob-gyn patients were slightly older than postnighttime ones (TABLE 1).

Physician characteristics are provided in TABLE 2 for the 86 surgeons (17.5%) and 134 obstetricians/gynecologists (40.5%) who performed postnighttime and matched control procedures. The mean and median number of postnighttime and control procedures per physician are provided in TABLE 3. The most common operating room procedures were gynecologic, digestive, and cardiovascular cases.

Procedural Complications in Postnighttime and Control Procedures

Results of the electronic administrative screens and medical record reviews are provided in the eFigure (available at http://www.jama.com). Clinician reviews determined that there were complications in 68 postnighttime operating room procedures (7.4%) and 253 operating room control procedures (7.1%) (OR of a post-

nighttime vs control procedure having at least 1 complication, 1.02; 95% CI, 0.74-1.40), and 55 and 251 preventable complications, respectively (OR, 0.88; 95% CI, 0.64-1.22; TABLE 4). We also found complications in 33 postnighttime L/D procedures (3.4%) and 112 L/D control ones (2.8%) (OR of a procedure having at least 1 complication, 1.21; 95% CI, 0.79-1.84), and 32 and 100 preventable complications, respectively (OR, 1.30; 95% CI, 0.85-1.99; Table 4). The adjusted ORs from the multivariable model were similar to the unadjusted ORs. The interrater reliability for clinician ratings for the presence, severity, and preventability of complications were good: $k = 0.83$, 0.78, and 0.60, respectively.

Table 4. Complications in Postnighttime vs Control Procedures

	No. (%) of Procedures		Adjusted OR (95% CI)[b]
	Postnighttime[a]	Control[a]	
Operating room	(n=919)	(n=3552)	
Procedures with complications	68 (7.4)	253 (7.1)	1.02 (0.74-1.40)
Total complications	69 (7.5)	279 (7.8)	0.97 (0.74-1.26)
Preventable complications	55 (6)	251 (7)	0.88 (0.64-1.22)
Labor and delivery	(n=957)	(n=3945)	
Procedures with complications	33 (3.4)	112 (2.8)	1.21 (0.79-1.84)
Total complications	35 (3.6)	112 (2.8)	1.29 (0.88-1.88)
Preventable complications	32 (3.3)	100 (2.5)	1.30 (0.85-1.99)
All procedures	(n=1876)	(n=7497)	
Procedures with complications	101 (5.4)	365 (4.9)	1.09 (0.84-1.41)
Total complications	104 (5.5)	391 (5.2)	1.06 (0.85-1.32)
Preventable complications	87 (4.6)	351 (4.7)	1.00 (0.77-1.29)

Abbreviations: CI, confidence interval; OR, odds ratio.
[a] Percentage of procedures with complications indicates number of procedures with complications per 100 procedures. Percentage of complications indicates number of complications per 100 procedures.
[b] ORs are adjusted for patient age, comorbidities, and sex.

Table 5. Types of Complications

	No. (%) of Operating Room Procedures			No. (%) of Labor and Delivery Procedures		
	Postnighttime	Control	*P* Value	Postnighttime	Control	*P* Value
Surgical site infection						
Superficial incisional	5 (7.2)	17 (6.1)		5 (14.3)	43 (38.4)	
Deep incisional	6 (8.7)	21 (7.5)		8 (22.9)	10 (8.9)	
Organ/space without abscess	1 (1.4)	9 (3.2)	.53	2 (5.7)	4 (3.6)	.83
Organ/space with abscess	1 (1.4)	15 (5.4)		2 (5.7)	0	
All infections	13 (18.8)	62 (22.2)		17 (48.6)	57 (50.9)	
Bleeding						
Massive hemorrhage	6 (8.7)	16 (5.7)		4 (11.4)	9 (8.0)	
Hematoma	5 (7.2)	23 (8.2)		0	10 (8.9)	
Artery damage	5 (7.2)	12 (4.3)	.36	1 (2.9)	9 (8.0)	.21
Vein damage	2 (2.9)	7 (2.5)		0	0	
All bleeding	18 (26.1)	58 (20.8)		5 (14.3)	28 (25.0)	
Organ/visceral injury						
Bowel/esophagus/stomach	6 (8.7)	30 (10.8)		1 (2.9)	8 (7.1)	
Spleen	0	2 (0.7)		0	0	
Lungs/heart	1 (1.4)	15 (5.4)		0	0	
Bladder/ureter	2 (2.9)	13 (4.7)	.18	4 (11.4)	6 (5.4)	.19
Uterus/ovary/fallopian tubes	1 (1.4)	5 (1.8)		1 (2.9)	6 (5.4)	
Perineum/vulva/cervix	2 (2.9)	5 (1.8)		5 (14.3)	3 (2.7)	
All organ/visceral injury	12 (17.4)	70 (25.1)		11 (31.4)	23 (20.5)	
Wound failure						
Dehiscence	2 (2.9)	16 (5.7)		0	0	
Anastomotic failure/fistula	2 (2.9)	14 (5.0)		0	0	
Hernia, incisional or internal	2 (2.9)	10 (3.6)	.81	0	0	.70
Other wound failure/seroma	8 (11.6)	20 (7.2)		1 (2.9)	2 (1.8)	
All wound failure	14 (20.3)	60 (21.5)		1 (2.9)	2 (1.8)	
Miscellaneous						
Neural damage/neuropathy	2 (2.9)	13 (4.7)		0	0	
Fracture/dislocation	1 (1.4)	2 (0.7)		1 (2.9)	2 (1.8)	
Redo or failed procedure	7 (10.1)	9 (3.2)		0	0	
Wrong site/retained foreign object	0	0	.09	0	0	.71
Intraoperative cardiac arrest	0	2 (0.7)		0	0	
Other	2 (2.9)	3 (1.1)		0	0	
All miscellaneous	12 (17.4)	29 (10.4)		1 (2.9)	2 (1.8)	
All complications	69[a]	279[a]	.52	35[a]	112	.37

[a] Complication totals differ slightly from procedure totals shown in the eTable and eFigure (available at http://www.jama.com) because some procedures had multiple complications during a single case.

Table 6. Duration of Sleep Time Opportunity and Extended Work Shift and Complications

No. of Hours	No. of Procedures With Complications/ Total No. of Procedures (%)	Adjusted OR (95% CI)[a]	*P* Value
Duration of sleep opportunity[b]			
0-6 Operating room	62/728 (8.5)	2.70 (1.13-6.48)	.03
>6 Operating room	6/191 (3.1)		
0-6 L/D	20/589 (3.4)	0.96 (0.47-1.95)	.91
>6 L/D	13/368 (3.5)		
0-6 All	82/1317 (6.2)	1.72 (1.02-2.89)	.04
>6 All	19/559 (3.4)		
Duration of extended work shift[c]			
0-12 Operating room	24/398 (6)	1.35 (0.78-2.38)	.27
>12 Operating room	44/521 (8.5)		
0-12 L/D	15/520 (2.9)	1.45 (0.72-2.94)	.30
>12 L/D	18/437 (4.1)		
0-12 All	39/918 (4.3)	1.47 (0.96-2.27)	.08
>12 All	62/958 (6.5)		

Abbreviations: CI, confidence interval; L/D, labor/delivery; OR, odds ratio.
[a] Odds ratios are adjusted for patient age, comorbidities, and sex.
[b] Duration of sleep opportunity is calculated as the interval of hours between end of last overnight procedure and start of first morning procedure.
[c] Duration of extended work shift is calculated as the interval of hours between start of first overnight procedure and end of each daytime procedure. For multiple or consecutive daytime procedures on the same day following an overnight procedure, each daytime procedure is associated with a unique and increasingly longer work duration.

The severity of complications associated with the postnighttime and control operating room procedures was judged as follows: unable to determine or insignificant, 0 and 3 (1.1%); significant, 25 (36.2%) and 112 (40.2%); serious, 42 (60.9%) and 144 (51.7%); life-threatening, 2 (2.9%) and 13 (4.7%); and fatal, 0 and 7 (2.5%), respectively (*P* = .84).

The severity of complications associated with the postnighttime and control L/D procedures was judged as follows: unable to determine or insignificant, 1 (2.9%) and 2 (1.8%); significant, 25 (71.4%) and 74 (66.1%); serious, 9 (25.7%) and 32 (28.6%); and life-threatening, 0 and 4 (3.6%), respectively (*P* = .98).

The most common surgical complications were organ injuries and bleeding; surgical site infections and organ injury were the most common obstetrical complications. We did not detect a difference in types of complications between postnighttime and control procedures (TABLE 5). Complicated postnighttime and control operating room procedures (135 and 129 minutes, respectively) were longer than uncomplicated procedures (64.5 and 66.2 minutes; eTable, available at http://www.jama.com). Similarly complicated postnighttime and control L/D procedures (71.5 and 60.4 minutes, respectively) were longer than uncomplicated procedures (46.5 and 44.8 minutes). The overall duration of postnighttime L/D procedures (47.2 minutes) was longer than for control procedures (45.2 minutes; *P* = .002).

Among postnighttime cases, a higher rate of procedural complications occurred when there were 6 or fewer hours of sleep opportunity (6.2%) compared with postnighttime procedures in which there were more than 6 hours of sleep opportunity (3.4%) (OR, 1.72; 95% CI, 1.02-2.89); this was predominantly due to operating room (surgical) complications (8.5% vs 3.1%, respectively). Postnighttime procedures performed when work duration exceeded 12 hours showed nonsignificantly higher complication rates compared with shifts of 12 hours or less (6.5% vs 4.3%; OR, 1.47; 95% CI, 0.96-2.27) (TABLE 6).

COMMENT

Procedures performed the day after attending surgeons and obstetricians/gynecologists worked at some point during the night were not associated with significantly increased complication rates compared with control cases that were not preceded by nighttime work. However, the duration of sleep opportunity available to surgeons and obstetricians/gynecologists following overnight cases varied widely. Among surgical (operating room) but not obstetrical/gynecologic (L/D) postnighttime cases with 6 hours or less of sleep opportunity, there was a substantially elevated rate of complication compared with cases in which sleep opportunity exceeded 6 hours. Furthermore, we found a nonsignificant increase in the risk of complications among combined operating room and L/D cases for work durations greater than 12 hours as compared with shifts of 12 hours or less. These data suggest that attending physicians, like residents and nurses,[1,19] may be at increased risk of making errors when sleep deprived or working extended shifts.

Our findings add to the limited literature on the effects of attending physician sleep deprivation and extended work shifts on clinical outcomes. In a study of surgical errors, fatigue was self-reported as a contributing factor in 16% of preventable adverse events.[20] Ellman et al[4] conducted a retrospective study of adverse outcomes in cardiac surgical procedures performed by sleep-deprived surgeons performed within the 24-hour interval following an overnight procedure. They found no difference in complication rates in procedures conducted by sleep-deprived vs nonsleep-deprived surgeons. Similar to Ellman et al,[4] we found no overall difference in complication rates among those performing surgery after working during the night, although both limited sleep opportunity and increased work duration predicted increased complication rates.

The 2008 Institute of Medicine report on resident duty hours did not comment on attending physician work hour limitations.[21] It remains unclear whether aging attending physicians are more or less able to cope with the physiologic effects of extended work shifts and fatigue than are younger resident physicians.[22] A recent survey found that attending physicians generally have greater concerns than do residents about the potentially

harmful effects of work hour restrictions for trainees on their professional development.[23] Attending physicians may be less likely to acknowledge the potentially harmful effects of extended work shifts than trainees. Some attending physicians may also be less inclined than residents to postpone electively scheduled surgical procedures even when they are aware of the possibility of decreased alertness from insufficient overnight sleep.

Measures to reduce attending physician extended-duration work shifts have the potential to influence patient care. Although our results suggest that improving sleep opportunities may improve care, work hour restrictions could also lead to disruptions in care continuity or delays.[24] Continuity of care is not a major issue, however, when considering appropriate rest periods between the performances of procedures on different patients.

There have been no US legislative or professional initiatives concerning sleep deprivation or work hours for attending physicians.[25] While noncompliance with the Accreditation Council for Graduate Medical Education resident work hour standards has been problematic,[26] attending physician work schedule restrictions would likely be even more challenging to monitor, enforce, and achieve. European restrictions on attending and resident physician work schedules have been complicated by increased surgical staff requirements and staff shortages.[27]

Our data suggest that the business as usual of a "limitless work week" for attending physicians is not optimal for patient care.[25] Several initiatives could mitigate the risks of unsafe levels of fatigue during procedures. Large physician groups can avoid scheduling elective procedures following overnight on-call responsibilities or use hospital-based clinicians, such as obstetrical "laborists" and surgical hospitalists, to cover nighttime emergencies.[28,29] A culture of teamwork,[30] along with critical redesign of schedules, can mitigate the chance of unduly fatigued attending physicians performing procedures.[10,31] When possible, adequate backup personnel should be available to relieve physicians who detect impaired performance due to severe fatigue in themselves and others.[32] Better sleep hygiene or the appropriate use of caffeine as a stimulant should be considered.[10]

Individuals should be educated about the effects of sleep deprivation on performance and how to recognize its effects. While cancellations following sleep-deprived nights are uncommon and may cause emotional and logistical challenges for patients and staff,[33] attending physicians should consider canceling or postponing elective procedures if they are not alert enough to safely operate. While technologies exist for monitoring alertness during certain tasks such as driving, they have not been tested for use as a "fitness for duty test" in health care or other settings.

Our study has several limitations including possible unidentified confounders or biases not accounted for in a retrospective cohort study. Our results might not be generalizable, especially to nonteaching hospitals; the presence of resident physicians may either have compensated for the effects of attending physician fatigue or have added to it if the residents themselves were sleep deprived. While most of the physicians in our study primarily operated at the study hospital, we were unable to determine if the rested attending physicians conducted overnight emergency procedures elsewhere. We were unable to determine if additional surgeons and obstetricians/gynecologists were requested to assist postnighttime procedures. We were also unable to identify if the physicians who performed control procedures were actually awake overnight. Judging the preventability of complications may have been affected by reviewers' hindsight bias.

CONCLUSIONS

We found that the rate of complications for surgeons and obstetricians/gynecologists who performed procedures the preceding night in our study hospital was not higher overall than for those who did not. Surgeons who had limited opportunity for sleep had significantly higher rates of complications than those who had a longer sleep opportunity. We did not observe an increased rate of complication among obstetricians/gynecologists who had limited opportunity for sleep; but given the lower rate of complications in labor and delivery as compared with surgery, larger studies with increased statistical power will be needed to further explore the effects of sleep deprivation in this setting.

Prospective studies are needed to more definitively quantify the effects of sleep deprivation on attending physicians across specialties, and to determine the safety of performing surgery after working at night in nonteaching settings. For situations in which it is necessary for attending physicians to conduct life-saving procedures following overnight work, effective strategies to minimize the effects of fatigue should be adopted into practice.

Author Contributions: Dr Rothschild had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.
Study concept and design: Rothschild, Keohane, Lipsitz, Czeisler, Bates, Landrigan.
Acquisition of data: Rothschild, Keohane, Yoon, Williams, Wien.
Analysis and interpretation of data: Rothschild, Keohane, Rogers, Gardner, Lipsitz, Salzberg, Yu, Yoon, Wien, Landrigan.
Drafting of the manuscript: Rothschild, Keohane, Wien, Landrigan.
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REFERENCES

1. Landrigan CP, Rothschild JM, Cronin JW, et al. Effect of reducing interns' work hours on serious medical errors in intensive care units. *N Engl J Med*. 2004; 351:1838-1848.

2. Ayas NT, Barger LK, Cade BE, et al. Extended work duration and the risk of self-reported percutaneous injuries in interns. *JAMA*. 2006;296(9):1055-1062.

3. Barger LK, Cade BE, Ayas NT, et al; Harvard Work Hours, Health, and Safety Group. Extended work shifts and the risk of motor vehicle crashes among interns. *N Engl J Med*. 2005;352(2):125-134.

4. Ellman PI, Law MG, Tache-Leon C, et al. Sleep deprivation does not affect operative results in cardiac surgery. *Ann Thorac Surg*. 2004;78(3):906-911.

5. Sachs BP. A 38-year-old woman with fetal loss and hysterectomy. *JAMA*. 2005;294(7):833-840.

6. Fletcher KE, Davis SQ, Underwood W, Mangrulkar RS, McMahon LF Jr, Saint S. Systematic review: effects of resident work hours on patient safety. *Ann Intern Med*. 2004;141(11):851-857.

7. Lydon-Rochelle M, Holt VL, Martin DP, Easterling TR. Association between method of delivery and maternal rehospitalization. *JAMA*. 2000;283(18):2411-2416.

8. Romano PS, Yasmeen S, Schembri ME, Keyzer JM, Gilbert WM. Coding of perineal lacerations and other complications of obstetric care in hospital discharge data. *Obstet Gynecol*. 2005;106(4):717-725.

9. Forster AJ, Fung I, Caughey S, et al. Adverse events detected by clinical surveillance on an obstetric service. *Obstet Gynecol*. 2006;108(5):1073-1083.

10. Landrigan CP, Czeisler CA, Barger LK, Ayas NT, Rothschild JM, Lockley SW; Harvard Work Hours, Health and Safety Group. Effective implementation of work-hour limits and systemic improvements. *Jt Comm J Qual Patient Saf*. 2007;33(11)(suppl): 19-29.

11. Agency for Healthcare Research and Quality. *AHRQ Quality Indicators-Guide to Patient Safety Indicators: 03-R203*. Rockville, MD: Agency for Healthcare Research & Quality; 2003.

12. Iezzoni LI, Daley J, Heeren T, et al. Identifying complications of care using administrative data. *Med Care*. 1994;32(7):700-715.

13. Karson AS, Bates DW. Screening for adverse events. *J Eval Clin Pract*. 1999;5(1):23-32.

14. Mann S, Pratt S, Gluck P, et al. Assessing quality in obstetrical care. *Jt Comm J Qual Patient Saf*. 2006; 32(9):497-505.

15. Weissman JS, Rothschild JM, Bendavid E, et al. Hospital workload and adverse events. *Med Care*. 2007;45(5):448-455.

16. Bates DW, Cullen DJ, Laird N, et al. Incidence of adverse drug events and potential adverse drug events. *JAMA*. 1995;274(1):29-34.

17. Breslow NE, Clayton DG. Approximate inference in generalized linear models. *J Am Stat Assoc*. 1993;88(421):9-25 doi:10.2307/2290687.

18. Woflinger R, O'Connell M. Generalized linear mixed models. *J Statist Comput Simulation*. 1993; 48(3-4):233-243 doi:10.1080/00949659308811554.

19. Rogers AE, Hwang W-T, Aiken LH, Dinges DF. The working hours of hospital staff nurses and patient safety. *Health Aff (Millwood)*. 2004;23(4): 202-212.

20. Gawande AA, Zinner MJ, Studdert DM, Brennan TA. Analysis of errors reported by surgeons at three teaching hospitals. *Surgery*. 2003;133(6):614-621.

21. Institute of Medicine; Committee on Optimizing Graduate Medical Trainee (Resident) Hours and Work Schedules to Improve Patient Safety; National Research Council. *Resident Duty Hours: Enhancing Sleep, Supervision, and Safety*. Ulmer C, Wolman DM, Johns MME, eds. Washington, DC: The National Academies Press; 2008.

22. Dijk DJ, Duffy JF, Czeisler CA. Contribution of circadian physiology and sleep homeostasis to age-related changes in human sleep. *Chronobiol Int*. 2000; 17(3):285-311.

23. Hutter MM, Kellogg KC, Ferguson CM, Abbott WM, Warshaw AL. The impact of the 80-hour resident workweek on surgical residents and attending surgeons. *Ann Surg*. 2006;243(6):864-871, discussion 871-875.

24. Pape HC, Pfeifer R. Restricted duty hours for surgeons and impact on residents quality of life, education, and patient care. *Patient Saf Surg*. 2009;3 (1):3.

25. Hyman NH. Attending work hour restrictions: is it time? *Arch Surg*. 2009;144(1):7-8.

26. Landrigan CP, Barger LK, Cade BE, Ayas NT, Czeisler CA. Interns' compliance with accreditation council for graduate medical education work-hour limits. *JAMA*. 2006;296(9):1063-1070.

27. Büchler P, Kraus TW, Friess H, Buchler MW. Labor legislation in the European Union has impact on workforce management in surgical centers. *Surgery*. 2003;134(1):3-11.

28. Weinstein L. The laborist: a new focus of practice for the obstetrician. *Am J Obstet Gynecol*. 2003; 188(2):310-312.

29. Maa J, Carter JT, Gosnell JE, Wachter R, Harris HW. The surgical hospitalist: a new model for emergency surgical care. *J Am Coll Surg*. 2007;205 (5):704-711.

30. Makary MA, Sexton JB, Freischlag JA, et al. Patient safety in surgery. *Ann Surg*. 2006;243(5): 628.

31. Vincent C, Moorthy K, Sarker SK, Chang A, Darzi AW. Systems approaches to surgical quality and safety. *Ann Surg*. 2004;239(4):475-482.

32. American College of Obstetricians and Gynecologists. ACOG Committee Opinion #328: patient safety in the surgical environment. *Obstet Gynecol*. 2006;107(2 pt 1):429-433.

33. Gaba DM, Howard SK. Patient safety: fatigue among clinicians and the safety of patients. *N Engl J Med*. 2002;347(16):1249-1255.

