



# The impact of surgical start time on complications in gynaecological surgery: a retrospective cohort study

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**Background:** Surgical start time (SST) has been identified as a possible factor which can increase surgical morbidity and mortality. Poorer outcomes have been identified in many specialities when care is provided outside of usual work hours. Whilst current published literature has examined the relationship between SSTs and complications in gynaecological sub-specialties (gynaecological oncology and urogynaecology), none have looked into general benign gynaecology where there is a greater proportion of emergency cases. Few papers have discussed SST in relation to elective operating lists (EOLs). The primary objective is to evaluate if SST affects the risk of peri-operative complications in benign gynaecological surgery. The secondary objective is to determine if SST on EOLs affects complications risks.

**Methods:** This is a retrospective cohort study of all patients who underwent benign gynaecological surgery within an Australian Health District from 01/06/2016 to 30/06/2020. The exclusion criteria were gynaecological surgery for malignant disease and obstetric procedures. For SSTs, 'in-hours' is defined as Monday to Friday 0830-1700h. Morbidity is any complication occurring within 30 days of the index operation. Complications were summarised into the 16 hospital-acquired complications from the Australian Commission on Safety and Quality in Healthcare. The relationship between SST and complications was assessed with a linear model with a binomial link. Comparisons are made against Early AM time brackets. A Student t-test is used to compare patient groups. A chi-square test is used to compare univariate categorical data.

**Results:** Due to the retrospective nature of our study we were unable to control for confounders. The overall complication rate was 2.9% (390/13,428) with no cases of mortality. Compared to surgeries performed in the early morning, cases with SSTs outside of usual working hours have increased risks of complications, especially at night RR 2.49 (95% CI: 1.56–3.98, P<0.001). SST on EOLs does not affect the risks of complications (P=0.18).

**Conclusions:** The relative risk of complications is increased when benign gynaecological surgeries have SSTs outside of usual work hours. SST on EOLs does not have an impact. Consideration should be given to delaying non-critical procedures to in-hours on weekdays, and/or increasing resource allocation during out-of-hours periods to mitigate the risks of complications.

**Keywords:** Complications; gynaecology surgery; morbidity; mortality; surgical start time (SST)

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## Introduction

Gynaecological surgeries occur at all hours of the day. Morbidity and mortality caused by complications of surgical treatment is a major healthcare concern and there has been significant research invested to identify risk factors for poor outcomes (1,2).

Fatigue, long work hours, change-of-shift hand-offs, and the absence of specialised surgical teams are some risk factors that have been identified that can be mitigated through changes in work-place practices (1,2). Studies have also shown that surgical start time (SST) is a modifiable factor where poorer outcomes have been documented in multiple specialities when care is provided outside of usual work hours (3-13), and when operations are performed emergently compared to electively (14). SSTs that are later in the day for non-emergent cases have also been associated with higher mortality rates (8). Whilst there has been research examining the relationship between SSTs and complications in gynaecological sub-specialties (gynaecological oncology and urogynaecology) (15,16), none have been conducted in general benign gynaecology where there is a greater proportion of emergency cases. General benign gynaecology would also represent a greater proportion of all surgeries performed in gynaecology and the findings would be more applicable to a wider population. The risk of complications following gynaecologic surgery for benign tumours can be as high as 29% (17). Identifying a potentially modifiable risk factor such as SST could help reduce this high incidence of complications in benign gynaecologic surgery.

In addition, only a few papers have discussed SST in relation to elective operating lists (EOLs) (8,15,16). These papers have shown conflicting evidence—starting non-emergent cardiac cases later in the day is associated with 2 times higher absolute and risk-adjusted mortality (8), however there is no evidence that starting later in the day on an EOL has any impact on outcomes in gynaecological oncology (15) or urogynaecology (16).

The primary objective of this study is to determine whether SST impacts the risk of peri-operative complications in benign gynaecological surgery, including both elective and emergency cases. The secondary objective is to determine if there is a relationship between SST on EOLs and the risk of complications. We present the following article in accordance with the STROBE reporting checklist (available at <https://gpm.amegroups.com/article/view/10.21037/gpm-22-5/rc>).

## Methods

This is a retrospective cohort study of all benign gynaecological surgeries performed within our Local Health District between 1 June 2016 and 30 June 2020. This Local Health District offers gynaecological surgery at 3 of its institutions, including 1 tertiary and 2 district hospitals; combined they house 1,625 beds (18). All hospitals are teaching hospitals, accredited specialist training sites for obstetrics and gynaecology (O&G) trainees, and have elective gynaecological surgery and round-the-clock emergency gynaecological surgery services. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Western Sydney Local Health District Human Research and Ethics Committee (QA2004-13) and individual consent for this retrospective analysis was waived.

### *Subjects*

The inclusion criteria were all cases of both elective and emergency gynaecological surgery for benign indications. The exclusion criteria were gynaecological surgery for malignant disease as well as obstetric procedures. Gynaecological-oncology operations were excluded as they work within a dedicated, specialised multi-disciplinary team which may mitigate complication risks.

### *Measurements of complications and procedures*

Data for this study were retrieved from the gynaecological surgery databases maintained separately by each of the included departments of O&G. These databases capture information about patient demographics, the index surgery, the surgeons, and complications arising from the surgery for all gynaecological operations performed in accordance with the Australian Council on Healthcare Standards Performance Indicator Reporting recommendations (19). Data regarding intra-operative complications are collected contemporary to the surgery as they are required to complete the operation report which is an integrated part of the electronic medical record system used by the Local Health District. Post-operative complications are added to the database retrospectively. Morbidity is defined as surgical complications occurring within 30 days of the index operation and include intraoperative, postoperative and medical complications (19). Complications were summarised into the 16 listed Hospital-acquired complications from

the Australian Commission on Safety and Quality in Healthcare. Readmission within 30 days under gynaecology are considered secondary to complications arising from the antecedent surgery and readmissions under other specialities were not included. Mortality includes all deaths within 30 days of the index surgery.

#### *Assessment of SST and other clinical characteristics*

Our study defines elective surgery as booked non-emergent cases where patients are allocated to EOLs and are electively admitted for the planned procedure. All other surgeries are considered emergency cases. 'In-hours' is defined as Monday to Friday 0830-1700h, where elective surgeries are performed on a morning half-day (0830-1230h), afternoon half-day (1300-1700h) or all-day EOLs (0830-1700h). In-hours SSTs for both elective and emergency cases are divided into Early AM (0830-1029h), Late AM (1030-1259h), Early PM (1300-1459h) and Late PM (1500-1659h). 'Out-of-hours' SST brackets are defined as Evenings (Monday to Friday 1700-2059h), Weekends (Saturday and Sunday 0830-2059h) and Nights (2100-0829h). These brackets correspond with the O&G medical staff shifts and correlate well with anaesthetic and theatre nursing staff shift times, as each out-of-hours bracket has different staffing and theatre resources.

#### *Statistical analysis*

Demographic and clinical variables are summarised between surgeries with and without complications using percentages or medians and interquartile range. The relationship between SST and complications is assessed with a linear model with a binomial link. This method of assessment was chosen as the SST were placed into different, uneven categories which followed the O&G medical staff shifts and comparisons are made against Early AM time brackets, unless otherwise stated, as it is thought that surgeons and operating theatre teams would be the most well-rested at this time, with the least amount of time pressure to complete the procedure, and with optimal staffing of all hospital services. This is applicable to both EOLs and emergency surgeries. The results are summarised with relative risk (RR) and 95% confidence interval (95% CI). A Student *t*-test is used to compare patient groups. A chi-square test is used to compare univariate categorical data.

For all analyses, a P value  $\leq 0.05$  is considered statistically significant and is two-sided. Data was analysed using the SAS software version 9.4 (SAS Institute, Cary, NC, USA).

## **Results**

Of the 13,428 operations performed during the study period, complications occurred in 390 (2.9%). Elective surgeries made up 75% (10,056/13,428) of all cases, where 67.4% (n=263) of complications occurred during these procedures.

Characteristics of patients with complications are described in *Table 1*. A single complication occurred in 245 women, while 145 women had 2 or more complications. The most common intra-operative complication was haemorrhage and haematoma complicating a procedure (n=156). Readmission within 30 days (n=105) was the most common post-operative complication. Medication complications and cardiac complications were the most common medical complications (n=9 each) (*Table 2*). There were no cases of mortality.

### **SST**

A total of 12,474 (92.9%) operations had SSTs in-hours, 432 (3.2%) on Evenings, 250 (1.9%) on Weekends, and 272 (2.0%) at Night. Of the 390 cases with complications, 336 (86.2%) occurred in-hours, 20 (5.1%) during Evenings, 15 (3.8%) on Weekends and 19 (4.9%) at Night (*Table 3*). The relative risk of complications occurring out-of-hours was significantly higher than occurring in-hours RR 2.36 (95% CI: 1.79–3.12,  $P < 0.001$ ). When compared to Early AM, there was no difference in the risk of complications between any of the in-hours time periods but the risk of complications was significantly increased for all out-of-hours time brackets with Evenings RR 2.14 (95% CI: 1.27–3.6,  $P = 0.001$ ), Weekends RR 2.14 (95% CI: 1.27–3.6,  $P = 0.004$ ), and the highest relative risk occurring at Night, RR 2.49 (95% CI: 1.56–3.98,  $P < 0.001$ ). Analysis by day of the week revealed that cases with complications occurred in relatively equal frequency during the weekdays (2–3%) and were more frequent on weekends (8%).

### **EOLs**

There were no statistically significant differences in the

**Table 1** Characteristics of patients who had surgical complications during benign elective and emergency gynaecological surgery

Variable	Patients with complications (N=390)	All patients (N=13,428)
Age (years)	Mean 41.4; median 38	Mean 41.9; median 40
<20	5 (1.3%)	196 (1.5%)
20–29	79 (20.4%)	2,076 (15.5%)
30–39	128 (32.8%)	4,305 (32.1%)
40–49	95 (24.3%)	3,486 (26.0%)
50–59	34 (8.7%)	1,887 (14.1%)
60–69	31 (7.9%)	884 (6.6%)
70	18 (4.6%)	594 (4.4%)
Body mass index (kg/m <sup>2</sup> )	Mean 28.5; median 28	Mean 26.6; median 28.4
<18.5	11 (2.8%)	63/2,216 (2.8%)
18.5 to <25	141 (36.2%)	794/2,216 (35.8%)
25 to <30	120 (30.7%)	663/2,216 (29.9%)
30 to <35	86 (22.1%)	332/2,216 (15.0%)
35 to <40	23 (5.9%)	179/2,216 (8.1%)
≥40	9 (2.3%)	185/2,216 (8.3%)
American Society of Anaesthesiologists Classification (ASA)		
1	236 (60.5%)	3,325/7,559 (43.9%)
2	83 (21.3%)	3,429/7,559 (45.4%)
3	71 (18.2%)	784/7,559 (10.4%)
4	0	21/7,559 (0.3%)
5	0	0
6	0	0
Operator		
Registrar	191 (49.0%)	4,736 (35.3%)
Consultant	199 (51.0%)	8,692 (64.7%)
Type of surgery*		
Minor	235 (60.3%)	10,034 (74.7%)
Major	155 (39.7%)	3,394 (25.3%)

\*, “minor” includes minor vaginal surgery, level 1–2 laparoscopy, and non-operative hysteroscopy; “major” includes major vaginal surgery, level 3–5 laparoscopy, any laparotomy, and operative hysteroscopy. Levels of laparoscopy are classified as per the Royal Australian and New Zealand College of Obstetricians and Gynaecologists and the Australasian Society of Endoscopy & Surgery Society.

**Table 2** Complications\*

Complications	Number
Intraoperative complications	
Haemorrhage and haematoma complicating a procedure	156
Organ damage	115
Postoperative complications	
Ileus	3
Infection	45
Readmission within 30 days	105
Unplanned admission	50
Unplanned admission to intensive care unit	32
Unplanned return to the operating room	42
Medical complications	
Cardiac complications	9
Delirium	1
Endocrine complications	1
Medication complications	9
Renal failure	4
Respiratory complications	6
Venous thromboembolism	2

\*, categorised as hospital-acquired complications from the Australian Commission on Safety and Quality in Healthcare.

risks of complications occurring with SSTs during any of the half-day EOL time brackets (i.e., Late AM, Early PM, Late PM) when compared to having an SST during the Early AM time bracket of half-day EOLs (Table 4).

The relative risk of complications occurring during all-day EOLs was significantly higher than during morning half-day EOLs RR 1.87 (95% CI: 1.37–2.54,  $P < 0.001$ ). However, when comparing the risk of complications where the SST is during the Early AM bracket of all-day EOLs to having an SST during other time brackets of all-day EOLs (Late AM, Early PM, Late PM), there were no statistically significant differences.

### Emergency surgeries

The majority of emergency surgeries occurred in-hours (74.6%,  $n=2,516/3,372$ ). Emergency procedures with SSTs out-of-hours had significantly higher risks of complications compared to in-hours, RR 2.17 (95% CI: 1.54–3.06,  $P < 0.001$ ). When compared to emergency operations with SSTs in the Early AM time bracket, there were no differences in the risk of complications where the SST was during the other in-hours time brackets (i.e., Late AM, Early PM, Late PM), but the risk was significantly higher for all of the out-of-hours periods—Evenings RR 2.04 (95% CI: 1.17–3.58,  $P=0.01$ ), Weekends RR 2.04 (95% CI: 1.17–3.58,  $P=0.02$ ) and Nights RR 2.38 (95% CI: 1.35–4.2,  $P=0.002$ ).

**Table 3** SST and the risk of complications during benign gynaecological elective and emergency surgery

Time categories	Complications	RR (95% CI)	P value
Early AM	125/4,460 (2.8%)	1	<0.001
Late AM	71/2,856 (2.5%)	0.89 (0.67, 1.18)	0.41
Early PM	109/3,807 (2.9%)	1.02 (0.79, 1.32)	0.87
Late PM	31/1,449 (2.1%)	0.76 (0.52, 1.13)	0.17
Evenings	20/334 (6.0%)	2.14 (1.35, 3.38)	0.001
Weekends	15/250 (6.0%)	2.14 (1.27, 3.60)	0.004
Night	19/272 (7.0%)	2.49 (1.56, 3.98)	0.0001
All in-hours	336/12,572 (2.7%)	1	<0.001
All out-of-hours	54/856 (6.3%)	2.36 (1.79, 3.12)	–

SST, surgical start time; RR, risk ratio; 95% CI, 95% confidence interval.

**Table 4** SST by operating list and the risk of complications during benign gynaecological elective and emergency surgery

Operating list type	Time categories	Complications	RR (95% CI)	P value
All elective cases (N=10,056)	Early AM	97/3,505 (2.8%)	1	0.18
	Late AM	52/2,183 (2.4%)	0.86 (0.62, 1.20)	0.38
	Early PM	94/3,242 (2.9%)	1.05 (0.79, 1.39)	0.74
	Late PM	20/1,126 (1.8%)	0.64 (0.40, 1.03)	0.07
	Half day AM	111/4,830 (2.3%)	1	<0.001
	Half day PM	91/3,805 (2.4%)	1.04 (0.79, 1.37)	0.78
	All day	61/1,421 (4.3%)	1.87 (1.37, 2.54)	<0.0001
Half day lists (N=8,635)	Early AM	73/3,037 (2.4%)	1	0.16
	Late AM	38/1,793 (2.1%)	0.88 (0.60, 1.30)	0.52
	Early PM	77/2,848 (2.7%)	1.12 (0.82, 1.54)	0.47
	Late PM	14/957 (1.5%)	0.61 (0.35, 1.07)	0.09
All day lists (N=1,421)	Early AM	24/468 (5.1%)	1	0.69
	Late AM	14/390 (3.6%)	0.70 (0.37, 1.33)	0.70
	Early PM	17/394 (4.3%)	0.84 (0.46, 1.54)	0.84
	Late PM	6/169 (3.6%)	0.69 (0.29, 1.66)	0.69
Emergency cases (N=3,372)	Early AM	28/955 (2.9%)	1	0.002
	Late AM	19/673 (2.8%)	0.96 (0.54, 1.71)	0.90
	Early PM	15/565 (2.7%)	0.91 (0.49, 1.69)	0.75
	Late PM	11/323 (3.4%)	1.16 (0.58, 2.31)	0.67
	Evenings	20/334 (6.0%)	2.04 (1.17, 3.58)	0.01
	Weekends	15/250 (6.0%)	2.05 (1.11, 3.77)	0.02
	Nights	19/272 (7.0%)	2.38 (1.35, 4.20)	0.002
	In-hours	73/2,516 (2.9%)	1	<0.001
	Out-of-hours	54/856 (6.3%)	2.17 (1.54, 3.06)	–

SST, surgical start time; RR, risk ratio; 95% CI, 95% confidence interval.

## Discussion

There is strong evidence demonstrating increased complications and poorer outcomes when patient care is provided out of usual work hours (3-8,11,16). Our study further contributes to this by showing that the relative risk of peri-operative complications is increased when SSTs are outside of usual working hours.

Our data concurs with previous studies that have shown care provided or operations performed out-of-hours have higher risks of complications, and especially that the highest risk of complications occurs when the SST is at night (20-23). This may be due to extended work hours, fatigue

and disruption of circadian rhythms which are all associated with increased risk of near or actual errors and decreased vigilance (2,24,25). It has also been suggested that the higher complication risk overnight may be due to better resuscitation and better staffing during the daytime (26), as well as the diurnal variation in circulating levels of clotting factors, catecholamines, and endothelial cell function (27).

Furthermore, the type of surgeries performed at night, i.e., only emergency procedures, may contribute to the increased risk finding. Patients undergoing emergency surgery are inherently predisposed to worse outcomes given the nature of their presentation and surgery (14). For



example, emergency caesarean sections are associated with a higher risk of maternal and neonatal complications when compared to elective caesarean sections (28). It is difficult to distinguish if the increased morbidity seen out-of-hours, especially at night, is purely due to the STT or influenced by the critically urgent nature of the disease process requiring the emergency operation.

Our study shows that SST in relation to EOLs have no impact on the risk of complications and are concordant with other publications that have found that late SSTs do not carry an increased risk in morbidity compared to early SSTs (8,19,20). Although our study does initially suggest that having surgery on an all-day EOL may increase the relative risk of complications compared to a morning half day EOL, further sub-analysis does not reveal any differences in complication rates between the different SST time brackets within all-day EOLs. This would suggest that surgeon fatigue and pressure to finish the EOLs on time may not be as influential on risk of complications as hypothesised when it comes to EOLs. However, this finding may also simply reflect that the half-day versus all-day EOL analysis was not adequately powered due the small numbers of all-day EOL cases (n=1,421) compared to half-day EOL cases (n=8,635). Further research comparing surgical outcomes of half-day versus all-day EOLs with a larger number is needed to better determine if the duration of EOLs affects complication risks.

With regards to the patients who experienced complications, they occurred most frequently in young healthy women. This may reflect the patient population undergoing benign gynaecological surgery (*Table 1*). There were near equivocal numbers of complications occurring between O&G consultants (51%) and trainees (49%) as the primary operator for the surgeries, although when looking across all the surgeries, trainees were only listed as the primary surgeon in 35.3% of operations. This likely reflects the skill levels of the trainees, who because of their inexperience, are more likely to make errors resulting in surgical complications (29). It was not the focus of this study to examine the role of patient demographics and surgeon experience in contributing to surgical complications, however the authors recognise that all of these factors may be potential confounders.

The strengths of this study include its large sample size and our reliable electronic records. The data collected are mostly contemporary to the operations and are compulsorily completed as part of the operation report. In addition, the patient population who present to the 3

included hospitals of the Local Health District is diverse in age, BMI, socioeconomic status, and ethnic background meaning our findings are likely to be generalisable to the broader national or international population. Our study also made sure that the time brackets used reflected the shift times of our O&G departments which would ensure that the findings are applicable to the patient cohort and the work practices for the Local Health District. It is possible, however, that using different categorisations of time, we may identify other trends in complications that were not observed. There is no uniformity in defining 'in-hours', 'out-of-hours' and time brackets among any of the current published literature, likely because like us, each study tried to base their SST brackets on shift times at their own hospitals (2,26).

The main limitations of our study stem from its retrospective nature in that we are unable to establish causation but rather can only draw an association between SST and risk of complications. Additionally, postoperative complications were retrospectively recorded leaving it susceptible to recall bias as well as errors in data recording and collection. Postoperative complications were also harder to capture as the patients may have presented to other health institutions for care.

With the data available we could not control for other variables that may confound the effect of SST on the risk of complications, in particular the underlying acuity and risk of emergency surgeries. It has been shown that certain operative and team-based factors are associated with equivalent outcomes regardless of SSTs (13,15,16). Our databases did not collect information about the anaesthetic and nursing teams present at each case, nor did it collect data about other factors that can contribute to peri-operative morbidity such as postoperative care.

Our findings can be used to better counsel women who require urgent or emergent procedures and inform surgeons regarding the increased risk of peri-operative complications associated with surgeries performed outside of usual work hours. Surgeon discretion and consideration should be applied to delaying emergency surgeries (where possible) to in-hours although this decision must be balanced with risks to patients of deferring their operation. Delay of commencing emergency surgery—such as in the case of caesarean sections (30) and emergency noncardiac surgery (31)—is independently associated with an increased risk of morbidity and mortality. Consideration should also be given to increasing allocation of staff and resources during out-of-hours shifts to mitigate the increased risks of

performing surgeries outside of usual work hours.

This is the first paper looking at the association between SST and peri-operative complications in benign gynaecological surgery. Gynaecological surgeries performed outside of usual work hours, particularly at night, are associated with an increased relative risk of complications compared to procedures performed in-hours on weekdays which is consistent with findings in other surgical specialties. Our study also indicates that SST on an EOL has no impact on the risk of complications, suggesting either that surgeon fatigue and time pressures to finish EOLs on time may be overcome by other factors not identified in this study, or are simply not as big a factor in-hours as hypothesized. Overall, it adds further to the body of evidence that operating outside of usual work hours is associated with a higher risk of morbidity for patients and that surgery should be deferred where possible to in-hours to improve patient outcomes and safety. Consideration should also be given to increasing allocation of staff out-of-hours and overnight to mitigate these risks.

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### Footnote

*Reporting Checklist:* The authors have completed the STROBE reporting checklist. Available at <https://gpm.amegroups.com/article/view/10.21037/gpm-22-5/rc>

*Data Sharing Statement:* Available at <https://gpm.amegroups.com/article/view/10.21037/gpm-22-5/dss>

*Conflicts of Interest:* Both authors have completed the ICMJE uniform disclosure form (available at <https://gpm.amegroups.com/article/view/10.21037/gpm-22-5/coif>).

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*Ethical Statement:* The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Western Sydney Local Health District Human Research and Ethics Committee (QA2004-13) and individual consent for this retrospective analysis was waived.

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