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The composition of surgical teams in the operating room and its impact on surgical team performance in China

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Abstract
Background Previous studies on surgical team composition have shown that surgical team size had an independent impact on surgical performance in US and Canadian hospitals. We aimed to investigate the impact of team composition on surgical performance in two Chinese hospitals.
Methods General surgery procedures performed from April 2011 to June 2012 were retrospectively reviewed to record the number of attendees in the operating room (OR) and the procedure time (PT).
Results A total of 1,900 valid procedures, mostly laparoscopic, were performed during the study period. The mean PT was 90.5 min. On average, there were a total of 6 (range = 3–8) team members per procedure: 3 (range = 1–5) surgeons, 2 nurses, and 1 anesthesiologist. Unlike the data reported for the US and Canada, the number of nurses and anesthesiologists remained stable in most cases, whereas the number of surgeons differed by procedure. Multiple-regression analysis revealed that both the complexity of the operation and the team size significantly affected PT. When procedure complexity and patient condition were kept constant, adding one team member in our data analysis predicted an increase of 34.7 min in the PT.
Conclusion The surgical team size has a measurable effect on PT. Aside from surgical complexity, the team composition and member stability affected PT in the OR. Optimizing surgical teams and developing a strategy to maintain team stability are of great importance for improving OR efficiency.

Keywords Team size · Team composition · OR efficiency · General surgery · Communication · Team cooperation

Surgical teams and teamwork are critical for the successful performance of open or laparoscopic surgeries [1–3]. In the operating room (OR), a surgical team is composed of healthcare providers from several different medical modalities. The standard personnel for an OR include surgeons, anesthesiologists, and nurses. Although team members have received proficient training in their own specialties, they seldom have the opportunity to train together as a dedicated team; therefore, the team performance during a surgical procedure varies depending on the team's work experience [4, 5]. Among the many variables defining a team, composition (size and members) is an essential element; however, only a few studies have delved into the composition of surgical teams.

In general, a surgical team is composed of surgeons, anesthesiologists, and nurses. Other healthcare practitioners may also enter the OR when required. The healthcare practitioners called to the OR may include cardiologists, obstetricians, radiologists, and pathologists. The number of team members plays a critical role in enhancing team performance [2]. Baker et al. [2] put forward that adding a

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new team member's expertise may be critical for team performance. However, studies by Cassera et al. [6] and Zheng et al. [7] suggested that oversized teams can introduce difficulties in team communication and coordination, which may impede team performance.

This study was designed to examine the correlation between surgical team composition and operation performance by reviewing the records of surgery performed at the two affiliated teaching hospitals of Shantou University Medical College between April 2011 and June 2012. The study design followed that of two similar studies completed in Portland, OR, USA [6] and Vancouver, British Columbia, Canada [8]. Results from these two studies showed that change in team membership will independently affect team performance [6, 8]. We decided to investigate whether this result can be replicated using data collected from Chinese hospitals.

China's health system has unique characteristics and requires extra effort to investigate its efficiency in the OR. Unlike surgeons in Canada and the US who work independently after their residency training, junior surgeons in China are assigned to a group of senior surgeons, which forms a clear hierarchal structure. In China, a junior surgeon's performance in the OR is directly supervised by the senior surgeons of the team. OR nurses have less of an opportunity to leave the OR during assigned cases than their colleagues in Canada and the US. These differences in Chinese ORs make us believe that surgical team composition in China may have different features and effects on surgical performance. This was the motivation for us to further examine team composition and its impact on surgical performance using data collected from Chinese hospitals.

For this study we reviewed the medical records of all surgical procedures performed between April 2011 and June 2012. The procedure time, procedure types, and case attendees were obtained from the Operation Record Sheet. With these data we aimed to (1) clearly describe the composition of surgical team in each case, (2) determine the correlation between team composition and procedure time, and (3) compare the difference between the data collected from different hospitals in China, Canada, and the US.

Methods

Chart review

We reviewed general surgical cases performed at the general surgery departments by senior surgeons from April 2011 to June 2012. All the procedures were performed in the selected time frame and the data were noted from the operative records. Team information included the number of surgeons, anesthesiologists, nurses (scrub and circulating), and others. We recorded the patient's age, weight, gender, American Society of Anesthesiologists (ASA) score, procedure cost, procedure type, and procedure start and end times. Methods used in the study were approved by the ethics committee of the Medical College of Shantou University.

Measures

The surgical team size included all the attendees of the procedure, including anesthesiologists, surgeons, scrub nurses, and circulating nurses. For each procedure, procedure time (PT) was calculated from the start and end times of the surgery.

Following the method created by Zheng et al. [8], the procedure's complexity was assessed by the Index of Difficulty of Surgery (IDS). The details for calculating IDS were reported elsewhere [6, 7]. Briefly, the IDS was calculated based on the Relative Value Unit (RVU) of a performed procedure under the Current Procedural Terminology (CPT) established by American Medical Association [9]. In this study, the RVU value of each case was obtained from the website of American Medical Association (AMA). A higher RVU indicates a more complicated surgical procedure. If multiple procedures are performed during a procedure, the RVU of a secondary procedure is calculated by multiplying its RVU by 0.5 and then adding that value to the RVU of the primary procedure. After we established the RVU values of each procedure, the procedure RVU score was then normalized to 100 by dividing the procedure RVU by the maximum RVU within this data set. By applying the same algorithms for calculating the IDS we were able to compare our data with the data reported from the US and Canada.

Data analysis

Data regarding team size and composition were analyzed descriptively and quantitatively using SPSS ver. 16.0 (SPSS Inc., Chicago, IL, USA). We described the total number of people involved in each procedure. We further categorized team members into specialty groups and reported the data by the minimum, maximum, mean, median, and standard deviation.

Pearson's correlations were performed between the team composition and the surgical outcome measured by the PT. The emphasis of the study was on the composition of an effective surgical team for a given procedure, the impact on team performance of adding extra team members when required, and whether this impact differed based on the new team members' expertise and team work experience. For our study, multiple-regression analysis was performed in order to explore which factor(s) contribute(s) to the change in PT. The regression model used the PT as the

Table 1 Team composition, size and procedure length

	Anesthesiologist	Surgeon	Nurse	Other	Team size	IDS	ASA score	Patient age (year)	Procedure time (min)
Minimum	1.0	1.0	2.0	0	3.0	6.7	1.0	0.2	10
Maximum	1.0	5.0	2.0	1.0	8.0	71.2	4.0	90	535
Mean	1.0	3.0	2.0	0	6.0	22.2	2.1	47.9	90.5
SD	0	0.6	0	0.1	0.7	12.1	0.5	17.2	63.3

IDS index of difficulty of surgery, *ASA* American Society of Anesthesiologists

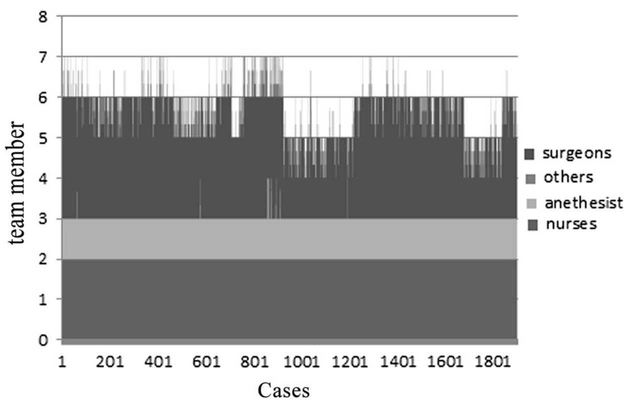

Fig. 1 Surgical team composition for 1,900 general surgical cases

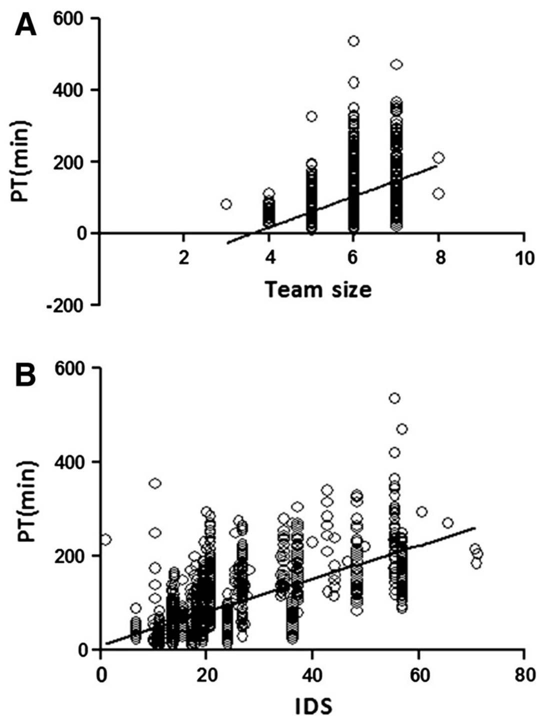

Fig. 2 Correlation between PT and team size (**A**) and IDS (**B**). *PT* procedure time, *IDS* index of difficulty of surgery

dependent variable; the independent variables included IDS, team size, ASA score, and patient age. Regression analysis was conducted using SPSS, with hierarchical data entry. Specifically, we enter the IDS into the model first, followed by the team size, and finally the ASA score and patient age at one time. The order of data entry was determined by the correlation coefficients between each predictor and PT. The variable with the highest simple correlation was entered into the model first.

Results

We reviewed 1,976 procedures performed during the selected time frame; 76 were excluded because of incomplete surgical records (e.g., unknown procedure length, missing information on OR personnel, or missing nursing records). Operations covered a wide range of general surgery procedures, laparoscopic or open, including cholecystectomy, appendectomy, thyroidectomy, inguinal hernia repair, radical resection of tumor, and liver and bile duct surgery.

Surgical team size and composition

The team size ranged from 3 to 8 people, with a mean of 6 team members assigned to a single procedure (Table 1). The surgical team included surgeons, anesthesiologists, nurses, and other experts or observers (Fig. 1).

All procedures analyzed were attended by an anesthesiologist and at least one surgeon and two nurses. Only 4.2 % ($n = 80$) of the procedures were performed by one surgeon. Two nurses (one scrub nurse and one circulating nurse) were seldom assigned to more than one OR at any given time, and they stayed during the entire procedure along with the surgeons and anesthesiologist. The attending anesthesiologist had full responsibility for the case during that procedure. Most procedures were performed by three surgeons ($n = 1103$, 58 %) or two surgeons ($n = 585$, 30.6 %).

Correlation between PT and team composition

Surgical team size (Pearson's $R = 0.460$, $P < 0.0001$) and IDS (Pearson's $R = 0.673$, $P < 0.0001$) were correlated with PT, patient age (Pearson's $R = 0.303$, $P < 0.0001$), and ASA score (Pearson's $R = 0.157$, $P < 0.0001$),

Table 2 Multiple-regression analysis

Model	*R*	R^2	Adjusted R^2	*F* value	*P* value
PT = 3.5IDS+11.8	0.677	0.458	0.458	1.604	0.000
PT = 3.1IDS+26.7Team size-130.48	0.730	0.532	0.532	1.079	0.000
PT = 3.0IDS+25.4Team size+10.1ASA-142.5	0.734	0.538	0.538	737.000	0.000
PT = 3.0IDS+25.2Team size+8.9ASA+0.148Age-144.9	0.735	0.540	0.539	555.411	0.000

Age patient age, *ASA* American Society of Anesthesiologists, *IDS* index of difficulty of surgery, *team size* number of team members

R denotes the correlation coefficients between the predictors and procedure length. R^2 (especially the adjusted R^2) is the percentage of variance in the dependent variable explained collectively by all of the independent variables. *F* is used to determine the significance of using the model to predict procedure length compared with a "best guess." The *P* value is used to estimate the improvement of the model in predicting the change in procedure length

Table 3 Multiple-regression output for regression coefficients

Model	Variable[a]	Unstandardized coefficients		Standardized coefficients	*t* value	*P* value
		B	SE	β		
1	(Constant)	11.808	2.237	–	5.278	0.000
	IDS	3.538	0.088	0.677	40.055	0.000
2	(Constant)	−130.480	8.476	–	−15.394	0.000
	IDS	3.097	0.086	0.592	36.022	0.000
	Team size	26.731	1.544	0.285	17.317	0.000
3	(Constant)	−142.519	8.748	–	−16.291	0.000
	IDS	3.043	0.086	0.582	35.363	0.000
	Team size	25.357	1.557	0.270	16.282	0.000
	ASA score	10.113	1.992	0.082	5.077	0.000
4	(Constant)	−144.908	8.798	–	−16.471	0.000
	IDS	2.984	0.090	0.571	33.285	0.000
	Team size	25.203	1.557	0.269	16.188	0.000
	ASA score	8.917	2.054	0.072	4.340	0.000
	Patient age	0.148	0.063	0.040	2.335	0.020

ASA American Society of Anesthesiologists, *IDS* index of difficulty of surgery

[a] Dependent variable: procedure time

respectively. Specifically, as the number of team members (Fig. 2A) or procedure complexity (Fig. 2B) increased, the procedure time also increased.

Multiple-regression analysis

We investigated the impact of team size, procedure complexity, and patient condition on team performance by performing a multiple-regression analysis on the PT (Table 2). When using IDS as the sole predictor (model 1 in Table 3), it accounted for 45.8 % of the variability in PT ($R^2 = 0.458$). When team size was added as a second predictor (model 2 in Table 3), it accounted for 53.2 % of the variability in PT ($R^2 = 0.532$). This means that team size accounted for an additional 7.4 % of the variability in PT. In model 4, when age and ASA were added, the four predictors accounted for 53.7 % of the variability in PT ($R^2 = 0.537$).

By using these values we can determine the specific impact of each of the predictors on the PT. The largest impact on the PT is from the IDS. For each regression model, SPSS also reported standardized regression coefficients (β) alone with the partial regression coefficients (B, Table 3). The β tells us to what degree each predictor affects the outcome when the effects of all other predictors are constant. For example, in model 4, the β values of the IDS, team size, ASA score, and age are 0.571, 0.269, 0.072, and 0.040, respectively. This means that a change in IDS of 1 unit (1 SD of IDS, or a value of 12.1) is associated with 0.571 unit (51.7 min, 0.571 × 90.5) variation of PT. The second greatest impact on the PT is from team size: 1 unit change of team size (1 SD of team size or 0.7 team member) predicts 0.269 unit (24.3 min, 0.269 × 90.5) change in PT. The data suggest that in a stable team setting, as was found in the ORs of China, changing the number of team members would be associated with a change of 34.7 min in the PT.

Discussion

This study produced valid data for us to use to describe the composition of the surgical teams in Chinese hospitals and gave us a chance to study the factors that influence team performance.

On average, six healthcare providers were assigned to a 90.5-min operation. Surgeons made up half of the team members, with the other half composed of anesthesiologists and nurses. Unlike teams as reported in the US and Canada, surgical teams in Chinese hospitals are composed of fewer members. In the ORs of Western countries, anesthesiologists and surgeons remain throughout the entire process but nurses are often shifted to other duties for various reasons such as lunch and coffee breaks [6]. In contrast, surgical teams in Chinese hospitals have less staff turnover during a surgical procedure. Team members tend to stay together until the end of the surgical procedure. High turnover and short-term involvement of other team members can jeopardize OR efficiency since the new team members have to be brought up to date with the current state of the procedure [5, 10, 11]. Full-procedure involvement of all the members of a Chinese surgical team enable team members in Chinese ORs to develop a greater connection with each other, which facilitates the development of cognition between team members regarding surgical tasks and goals.

It is interesting to further compare our results to those reported from the US and Canada. Our results show that changing the number of team members by one causes a change of 35 min in the PT, whereas the US and Canada data reported a 15- and 7-min change in the PT, respectively. We also believe that each member of a smaller but tightly knit team (such as Chinese teams) will have a greater impact on the PT than a larger but less connected team. The other consideration is team composition. Chinese teams change mainly when the surgeons change rather than scrub or circulating nurses, which may also explain why changing the number of team members will have a more direct impact on the PT than teams reported in US and Canadian hospitals.

Based on the evidence reported in the present study, we make the following recommendations for improving OR efficiency in Chinese hospitals. Instead of watching the nurses' role in the surgical teams, as suggested by the Cassera and Zheng [6, 7], Chinese surgical teams should try to optimize the composition of the surgeons, especially by clarifying the duties of each surgeon. When a surgical procedure is short, the stability of the surgical team needs to be maintained. For long procedures, better strategies to reinforce communication among team members, especially between senior and novice surgeons who are assigned to the surgical team in the later stages, need to be implemented. Human factors such as expertise, communication, workloads [12], and leadership [13] are key to team performance. Keeping a relatively fixed surgical team and enhancing communication among members are good ways for improving team performance. It is important for team members to communicate before surgery and during staff turnover to increase efficiency and this is done by forming the surgical team before surgery. It has been shown that appropriate safety measurements can lead to an improved outcome [5, 14]; it has been shown that going down checklists is a key safety process in the OR environment [15]. Furthermore, if variation in procedure times could be controlled or better predicted, the cost of surgery could be reduced through improved scheduling of surgical resources [16].

Again, medical systems vary from country to country. Where surgeons in Canada and the US work independently after the completion of their residency training, junior surgeons in China are supervised more carefully by a group of senior surgeons in the OR and clinics. Consequently, surgical teams tend to be a mixture of experts and novices in China. The different structure of surgical teams affects team performance as well as individual performance; novices in the mixed teams showed markedly better performances than they did in the purely novice teams [17]. OR efficiency needs to be compared between countries to provide more ideas on how to improve it.

For future studies, we can compare the different training modalities of surgeons in China and Western countries, and find better ways to teach novice surgeons and provide support for their performance in the OR. We will continue our research on OR efficiency by including more variables in determining surgical outcome to improve the safety of surgery, which will benefit our patients in China and around the world.

Conclusions

In this study we have described the team size and composition for general surgical procedures in Chinese ORs. We found the composition of surgical teams independently affects procedure time. Examining results from different hospital systems allowed us to determine a different strategy for improving OR efficiency. For Chinese teams, optimizing the surgical team and developing a strategy to maintain team stability are of great importance for decreasing procedure time.

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