


# Analysis of Surgical Resident Operative Volumes on China's Resident Training

Wei Liu<sup>1</sup>, Xiaoling Han<sup>1</sup>, Xu Zhou<sup>1</sup>, Chongzhi Zhou<sup>1</sup> and Min Wang<sup>2</sup> 

<sup>1</sup>Education Department, Shanghai General Hospital, Shanghai Jiaotong University School of Medicine, Shanghai, China. <sup>2</sup>Department of General Surgery, Shanghai General Hospital, Shanghai Jiaotong University School of Medicine, Shanghai, China.

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**ABSTRACT:** Doctors entering surgical residency with different educational degrees and from different specialties is a unique feature of the Chinese medical system. The effect of this on the experience of surgical residents is not known. We retrospectively investigated whether residents' operative volumes were based on highest educational degree or postgraduate specialty. Using our operating data management system, a retrospective analysis of surgical resident operative experience at Shanghai General Hospital from 2012 to 2017 was conducted. The overall monthly average operative volume for surgical residents was 17.7 (12.6–26.5), but this decreased with each advanced degree of education from 26.0 (19.2–34.5) for those with a bachelor's degree only, to 19.5 (16.0–28.1) for a master's degree, to 15.9 (12.2–22.9) for those with a doctorate. Regarding specialty, residents in plastic surgery had the highest operative volume, and those in cardiothoracic surgery and neurosurgery had the lowest. At Shanghai General Hospital, the operative volumes of surgical residents differed according to their highest educational degree and postgraduate specialty. This analysis should be useful for the future planning of surgical residency programs in China.

**KEYWORDS:** Residency, surgical proficiency, educational degrees, specialties

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**CORRESPONDING AUTHOR:** Min Wang, Department of General Surgery, Shanghai General Hospital, Shanghai Jiaotong University School of Medicine, No. 100, Haining Road, Hongkou District, Shanghai 200080, China. Email: wangmin0501@hotmail.com

## Introduction

China began standardized resident training in 2011, and the volume of enrolled residents has grown quickly.<sup>1,2</sup> Surgical practice is a combination of science and craft, with science referring to the knowledge and judgment involved, and craft the technical skill learned by working with a more senior surgeon in the operating room.<sup>3</sup> The paradigm of graded responsibility through which residents receive training in the operating room was introduced by William Halsted more than a century ago.<sup>4,5</sup> Although much has changed since then, the training and participation of residents in operative surgical practice remains of great importance.<sup>6</sup>

Shanghai General Hospital (SGH) is a tertiary hospital in eastern China, established in 1864. The training method at SGH is in accordance with Chinese national standards. This includes rotation among departments (general surgery, urology, orthopedics, neurosurgery, cardiothoracic surgery, and plastic surgery) and some nonsurgical departments (surgery intensive care unit, radiology, and pathology), and specific lectures concerning medical research and education. During the rotation, surgical residents participate in surgical procedures.

There are unique features associated with surgical residents in China.<sup>7–9</sup> Residents come to surgical residency with different highest educational degrees, including bachelor's, master's, and doctorate. The basic bachelors medical degree in China requires 5 years of education, a master's at least 3 years more, and a doctorate at least 3 years after that. Residents with master's and doctorate degrees also have their own specialties during their postgraduate studies. Those with only a bachelor's

degree choose a tutor with a surgical subspecialty at the beginning of residency. Thus, Chinese surgical residents come from different specialty backgrounds and have a variety of postgraduate educational experiences. However, despite differences in specialties or postgraduate educational attainment, all residents begin at the same level during their residency.

This retrospective study compared the operative experiences of residents at SGH from 2012 through 2017, bearing in mind their different backgrounds in education and specialties.

## Methods

This study was approved by the Institutional Review Board of SGH, Shanghai Jiaotong University School of Medicine.

For surgical residents, the duration of residency depends on their education degree: 3 years for a bachelor's degree, 2 years for a master's, and 1 year for those a doctorate. Residents rotate through surgical and nonsurgical departments (Table 1).

The operation room data management system records the participation of surgical residents in surgical procedures. From 2012 to 2017, 102 residents at SGH were enrolled in this study (Table 2).

For social and legal reasons, surgical residents in standardized residency training programs in hospitals in China are only rarely given the opportunity to act as the primary operating surgeon. This is because, first, patients do not wish to be operated on by surgeons in training. Legal issues restrict residents from performing complex surgery alone. In addition, surgery has become more specialized and the technology more complex, and the knowledge required has limited the opportunities





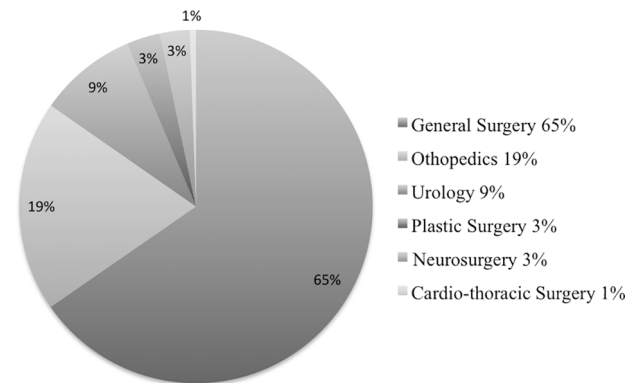
**Table 2.** Characteristics of the enrolled surgical residents, n (%).

Start year	
2012	13 (12.7)
2013	10 (9.8)
2014	14 (13.7)
2015	22 (21.6)
2016	23 (22.5)
2017	20 (19.6)
Gender	
Male	96 (94.1)
Female	6 (5.9)
Highest educational degree	
Bachelor's	14 (13.7)
Master's	16 (15.7)
Doctorate	72 (70.6)
Postgraduate specialties	
General surgery	21 (20.6)
Orthopedics	31 (30.4)
Urology	25 (24.5)
Cardio-thoracic surgery	14 (13.7)
Neurosurgery	5 (4.9)
Plastic surgery	6 (5.9)

for surgical residents to perform surgical procedures as the primary surgeon. Thus, surgical residents in the operating room usually act as assistants. In this study, the data concerned residents' operative volume as it related to their participation as first or second assistant. The job of first assistant is to provide direct support to primary surgeon, including assistance in visualization, hemostasis, closure, and exposure to surgeon during surgical procedures. The duty of second assistant is less important than first assistant, his main job is ensuring clear visibility for the surgeons using instruments such as retractors and sponges and providing assistance for first assistant when closing surgery sites and dressing wounds.

Surgery types were classified as basic or complex surgery according to Chinese surgical grading. Grade 1 and Grade 2 surgery were classed as basic surgery while Grade 3 and Grade 4 surgery were classed as complex surgery.

In this study, the operative volumes of residents with different educational degrees were compared. As their overall rotation duration is different, the residents' operative volumes were analyzed as the monthly average operative volume (MAOV), calculated as the total operative volume divided by the number of months of rotation in the surgical department.

**Figure 1.** Ratio of different specialty surgeries in which residents participated.

SPSS 20.0 (IBM Corp, Armonk, NY, USA) software was used for statistical analyses. The Kolmogorov-Smirnov test was applied to test the normality of the data. As the result showed that the data were not normally distributed, the significance of differences was determined through nonparametric methods, and the data are reported as median (25-75% quartile). For comparisons between 2 groups, the Mann-Whitney *U* Test was used to determine differences. When the comparison was among multiple groups, the Kruskal-Wallis test was used to determine differences.  $P < .05$  indicated a significant difference.

## Results

Among the 102 residents enrolled in this study, the overall MAOV was 17.7 (12.6, 26.5), and the basic and complex surgery volumes were 2.1 (0.9, 4.1) and 14.1 (10.0, 20.0), respectively. With residents acting as first or second assistant, the MAOVs were 4.8 (2.6, 7.4) and 12.5 (8.8, 16.7). Subgroup analyses showed that the MAOVs of residents participating as first assistant in basic and complex surgeries were 0.7 (0.2, 1.7) and 3.4 (1.7, 5.7). The MAOVs of residents acting as second assistant in basic and complex surgeries were 1.1 (0.4, 2.7) and 10.2 (7.0, 15.2).

Regarding the specialty surgeries in which the residents assisted, the largest proportion were in general surgery (65%) (Figure 1). In decreasing order of percentage, other surgical specialties were orthopedics (19%), urology (9%), neurosurgery (3%), plastic surgery (3%), and cardiothoracic surgery (1%).

When the residents were grouped according to highest educational degree (bachelor's, master's, or doctorate), comparisons showed significant differences in their total MAOVs, and the MAOVs related to overall participation as first or second assistant, or specifically as second assistant during basic surgery (Table 3). Residents with only bachelor's degrees participated in the most surgeries overall, and as second assistant. Residents with a master's degree participated in the most surgeries as first assistant, and as basic surgery first assistant. Residents holding a doctorate degree participated in the fewest surgeries in all situations.

**Table 3.** MAOVs associated with the highest educational degrees of the surgical residents.

	DOCTORAL DEGREE <sup>a</sup>	MASTER'S <sup>b</sup>	BACHELOR'S <sup>c</sup>	$\chi^2$	P
Total	15.89 (12.20-22.92)	19.50 (15.98-28.13)	26.04 (19.19-34.54)	6.941	.031
First assistant	3.95 (2.00-6.81)	6.89 (5.62-7.95)	6.28 (3.81-12.58)	9.083	.011
Second assistant	11.52 (8.80-16.08)	12.90 (8.58-16.02)	17.71 (12.85-21.78)	6.387	.041
Basic surgery first assistant	0.42 (0.12-1.14)	2.76 (0.96-4.88)	0.80 (0.20-2.41)	12.315	.002
Complex surgery first assistant	3.06 (1.55-5.11)	4.06 (2.26-5.99)	5.55 (2.18-7.06)	4.068	.131
Basic surgery second assistant	0.95 (0.33-2.56)	2.27 (0.55-4.39)	1.15 (0.61-2.71)	3.097	.213
Complex surgery second assistant	9.58 (6.75-14.25)	7.97 (5.20-15.32)	15.29 (10.15-18.70)	4.796	.091

Abbreviation: MAOV, monthly average operative volume.

<sup>a</sup>n = 72.

<sup>b</sup>n = 16.

<sup>c</sup>n = 14.

When considering the distribution of surgical specialties in which the different postgraduate specialties residents participated, there were significant differences in total MAOV, as second assistant, and during complex surgeries as first or second assistant (Table 4).

## Discussion

This retrospective study investigated the MAOVs of surgical residents at a major teaching hospital in Shanghai from 2012 through 2017. In China, residents in standardized residency training programs rarely have opportunities to perform as primary surgeons due to many reasons. First of all, it takes very long for the surgical residents to go through the currently widely promoted Chinese “3 + X + Y” training program, before they become attending doctors. An overview of the “3 + X + Y” model for general surgery is demonstrated in Table 5. In this 3-stage training model, the first number “3” represents 3 years of standardized residency training, on which this study focuses. It is also worth mentioning that in practice, the required duration of surgical residency often varies from 1 to 3 years, depending on the individual's *highest degree*. According to the Chinese regulation, residents with master's degrees could deduct 1 year from the 3, and residents with doctorate degree could deduct 2 years, because they have more surgical training time as interns before they formally graduate. After the standardized residency training stage, residents will have more time to practice as primary surgeons, especially in the “Y” stage.

Second, in the Chinese society, people generally do not trust young doctors. Patients always prefer senior surgeons with more experience and sometimes greater reputation. Moreover, becoming an attending doctor is only the beginning of a journey of continuous learning and practicing, for “attending” is not the highest title a doctor can achieve in China. Most patients would also prefer doctors with higher titles, such as “chief physician” or “associated chief physician,” both of which can be obtained by qualified attending

doctors. The time-consuming residency program and the bias against young doctors significantly reduce the chances for surgical residents to perform surgeries as primary surgeons. So in this study, we focused on the MAOVs of residents acting as a surgical assistant.

The overall MAOV was 17 with 2 basic cases and 14 complex cases. Our hospital is an academic center and receives many complex surgeries requests on daily basis, which explains a high proportion of complex cases. Moreover, the Chinese surgery grading system is different from the American one. For example, a significant portion of the complex surgeries are actually laparoscopic cholecystectomy, which is considered “complex” under the Chinese surgery grading system. In this study, we made a distinction between the first or the second surgical assistant. The job of first assistant is to provide direct support to the primary surgeon and the second assistant is less important. A junior resident usually acts as a second assistant first, then moves up to the first assistant as his experience grows. The role of first assistant usually assumed by a junior staff surgeon or a senior resident depending on the type of the surgeries.

The major finding of our study was that the MAOVs of residents differed significantly according to their highest educational degree and postgraduate specialty. In this study, residents with only bachelor's degrees had the highest volume of operations, while those with doctorates had the lowest. When residents were asked the major reason preventing them from more involvement in surgical procedures, all of those with only bachelor's degrees stated that they were preoccupied with too much administrative work, while 35% of residents with doctorates responded that there was not enough time to write research articles and funding grants, and also go to the operating room.

A study from the United States reported that restrictions in residents' duty hours led to an increase in the articles they published,<sup>10</sup> as they had more time for research. Balancing time spent on clinical work with time spent on research is a problem

**Table 4.** MAOVs associated with different postgraduate specialties.

	GS	UROLOGY	ORTHOPEDICS	CTS	NS	PS	$\chi^2$	P
Total	16.7 (10.8-24.6)	22.1 (17.3-33.7)	17.8 (13.5-26.8)	13.6 (10.5-17.9)	12.3 (10.8-22.9)	23.4 (5.2-30.3)	14.153	.015
First assistant	4.0 (3.1-9.3)	6.4 (4.3-9.2)	4.7 (1.9-6.6)	3.6 (1.7-6.4)	2.8 (2.0-7.2)	7.1 (2.0-16.2)	8.397	.136
Second assistant	13.0 (6.0-16.7)	16.1 (11.2-25.6)	11.8 (8.8-18.9)	9.9 (4.7-13.0)	9.5 (8.8-15.6)	13.0 (3.2-17.3)	11.281	.046
Basic surgery first assistant	0.7 (0.6-1.5)	0.6 (0.23-1.49)	0.8 (0.2-2.3)	0.4 (0.0-2.0)	0.2 (0.2-3.9)	3.1 (0.5-8.6)	4.888	.43
Complex surgery first assistant	3.5 (2.1-6.4)	5.0 (3.2-6.9)	2.5 (1.2-4.8)	2.6 (0.7-3.4)	2.6 (1.8-3.4)	4.4 (1.0-7.3)	11.606	.041
Basic surgery second assistant	1.1 (0.4-3.0)	1.2 (0.5-2.8)	1.0 (0.6-2.5)	0.4 (0.3-2.5)	0.6 (0.2-2.7)	4.21 (0.5-6.5)	3.814	.576
Complex surgery second assistant	9.9 (5.7-14.1)	13.8 (10.6-21.1)	9.6 (6.7-16.4)	7.8 (2.9-10.3)	9.1 (8.5-12.9)	7.1 (2.6-10.1)	15.804	.007

Abbreviations: CTS, cardiothoracic surgery; GS, general surgery; MAOV, monthly average operative volume; NS, neurosurgery; PS, plastic surgery. Number of residents in each specialty: general surgery, n=21; urology, n=25; orthopedics, n=31; cardiothoracic surgery, n=14; neurosurgery, n=5; plastic surgery, n=6.

**Table 5.** Standard Chinese surgical residents training program (the “3 + X + Y” model).

3 + X + Y MODEL		
3 years	X (2-3 years)	Y (1-3 years)
Residency (specialty training)		Fellowship (subspecialty training)
Postgraduate		

Abbreviations: X, general surgery specialty (2 years); surgical critical care medicine specialty (2 years); burn surgery specialty (2 years); Y: gastrointestinal surgery (1 year); colorectal surgery (1 year); hepatobiliary pancreatic surgery (2 years); thyroid and head and neck surgery (1 years); vascular surgery (2 years); transplant surgery (2 years).

for surgical residents worldwide. An increasing administrative load is also a growing problem for Chinese residents and limits time in the operating room. Promoting the use and simplification of the electronic medical record system may be a way to resolve this problem.

In this study, it was found that the residents with only bachelor's degrees were involved in more complex surgeries as a second assistant compared with the residents with postgraduate degrees. This suggests that residents with higher degrees who want a more important role in the operating room are prevented from doing so.

Another feature of surgical residency in China is that residents with different postgraduate specialties are enrolled in the same training programs. However, this study found that residents with different postgraduate specialties appeared to achieve different MAOVs. Those residents rotating through plastic surgery had the highest MAOV, while those in neurosurgery completed the least.

In general, the goal of resident training is to graduate doctors who can work independently and safely as surgeons.<sup>11,12</sup> In China specifically, the purpose is the acquisition of fundamental surgical skills. Resident training in China may be considered analogous to the first and second postgraduate years of surgery training in the United States. Residents spend most of the time rotating in general surgery and orthopedics, and are trained in basic skills that are important at the beginning of a doctor's career. As our resident training is only for general surgery, if residents want to work in a specialty, they must undergo advanced training in that specialty.

In traditional surgical training, residents' responsibilities during surgical procedures are gradually increased. Initially, residents observe and assist the senior surgeons, then take more responsibility over time and gain the opportunity to perform surgical procedures. Eventually, the residents become proficient enough to operate by themselves.<sup>13</sup> In China, residents cannot be a primary operating surgeon, but participating as an assistant is another way to gain operative experience. A well-known study showed that ~10,000 h of practice are required for a person to develop expertise in complex tasks, such as surgery.<sup>14,15</sup> We believe that time spent in the operating room to observe and assist more

senior surgeons as they perform complex procedures is an important part of surgical training. The experience gained from this real-time experience in the operating room is something that cannot be replaced by educational materials and simulations. Participating in operations as assistants is valuable for the experience and maturity of residents.

The medical education system in China is very different from that in America. Unlike America where all medical students adopt a 4 + 4 model, Chinese medical students may enter residents training with various degrees. Obviously, surgical residency in China is also vastly different from that in the United States. Medical students may enroll in the Chinese surgical residency with a Bachelor, Master, or Doctorate degree. There is no standardized path from college/university to medical school, and then to graduate medical education in a surgical discipline. Residents with different highest degrees do not share similar surgical backgrounds. Specifically, residents with postgraduate degrees have already gone through surgical trainings before graduation, making those with higher degrees less interested in their formal residency training.

Our study revealed that the MAOVs of residents depended crucially on their highest educational degree and postgraduate specialty. These results may have some implications for Chinese surgical education. In future, more standardized medical education system and surgical residents training system should be established in China, leading to more unified education path and high diversities in training content.

This study is limited by its retrospective nature and because the data are from a single institution. However, the advantage of our study is that an electronic record system was used to provide accurate data, while most institutions still use self-reported systems to assess the operative volume of residents.

## Conclusion

In conclusion, at SGH under the current standardized program for resident training, over the past 6 years, surgical residents with different educational degrees and from different specialties achieved different operative volumes. These are important issues to address as Chinese surgical residency programs are developed in the future.



## Author Contributions

MW and WL planned, designed and conceived the study. WL, MW and XLH drafted the manuscript. CZZ contributed to the interpretation of the data. XLH and XZ performed statistical analyses. MW and XLH piloted the survey. All authors read and approved the final manuscript.

## ORCID iD

Min Wang  <https://orcid.org/0000-0003-0101-1855>

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