

# EUS development in China: Results from national surveys in 2013 and 2020

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## ABSTRACT

**Background and Objectives:** EUS has recently gained attraction in mainland China. This study aimed to evaluate the development of EUS from results of two national surveys. **Methods:** EUS-related information, including infrastructure, personnel, volume, and quality indicator, was extracted from the Chinese Digestive Endoscopy Census. Data from 2012 and 2019 were compared, and differences among various hospitals and regions were analyzed. The EUS rates (EUS annual volume per 100,000 inhabitants) between China and developed countries were also compared. **Results:** The number of hospitals performing EUS in mainland China increased from 531 to 1236 (2.33-fold), and 4025 endoscopists performed EUS in 2019. The volumes of all EUS and interventional EUS increased from 207,166 to 464,182 (2.24-fold) and 10,737 to 15,334 (1.43-fold), respectively. The EUS rate in China was lower than that in developed countries but showed a higher growth rate. EUS rate varied substantially among different provincial regions (in 2019: 4.9–152.0 per 100,000 inhabitants) and showed significant positive association with gross domestic product per capita (in 2019:  $r = 0.559$ ,  $P = 0.001$ ). The EUS-FNA-positive rate in 2019 was comparable between hospitals in terms of annual volume ( $\geq 50$  or  $< 50$ : 79.9% vs. 71.6%,  $P = 0.704$ ) and practice duration (starting EUS-FNA before or after 2012: 78.7% vs. 72.6%,  $P = 0.565$ ). **Conclusion:** EUS has developed considerably in China in recent years but still needs substantial improvement. More resources are in demand for hospitals in less-developed regions and with low EUS volume.

**Key words:** development status, EUS, national census, quality

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## INTRODUCTION

EUS is an important technique for the diagnosis, staging, and treatment of gastrointestinal and pancreaticobiliary diseases. Globally, EUS has developed considerably in recent years,<sup>[1,2]</sup> and several national surveys from developed countries have shown that the volume of EUS has increased substantially.<sup>[3-5]</sup> However, reliable data on the trend of EUS growth in developing countries are vacant.

In 2013 and 2020, two national surveys of digestive endoscopy were conducted in mainland China, the largest developing country in the world.<sup>[6,7]</sup> The study aim was to analyze relevant data from the surveys for evaluating the development and potential problems of EUS over the past 7 years in China. This study may also provide useful information on EUS for other developing countries.

## METHODS

### *Survey organization*

The Chinese Digestive Endoscopy Census was conducted twice in 2013 and 2020 by the National Digestive Endoscopy Improvement System, and the overall organization was similar between the two surveys. All hospitals performing digestive endoscopy in mainland China were invited to participate in the surveys, which were facilitated by health authorities. The hospitals designated personnel to complete the online predesigned structured questionnaires. The details of the survey in 2013 and some of its results have been discussed previously.<sup>[6,7]</sup> In 2020, the quality of the collected data was assessed through a logical test via a computer and manual check by each provincial endoscopy quality control center. If the data were incomplete or failed to pass the logical verification, the questionnaire was returned and refilled. The final data were collected and checked in Shanghai.

### *Questionnaire content*

The factors involving EUS in both surveys included the general status of hospitals, number of EUS processors, and annual volume of EUS. EUS is broadly divided into diagnostic and interventional EUS (including EUS-FNA and various therapeutic interventions). Intraductal ultrasonography during ERCP was not included in this study. The contents of the survey in 2013 and 2020 were completed according to the data from 2012 and 2019, respectively. The survey in 2020

also included the number of endoscopists performing EUS, number of echoendoscopes (including radial or linear, but not miniprobe), and diagnostic rate for malignancy in patients receiving EUS-FNA of suspected malignant masses (EUS-FNA-positive rate). If atypical or malignant cells were found in a EUS-FNA sample, the result was defined as positive.

### *Definitions*

The EUS rate was defined as the total EUS volume per 100,000 inhabitants in a certain year and was used as the main index to evaluate the adequacy of EUS in a region. The EUS rates in other countries were retrieved or estimated from published reports<sup>[3-5,8-11]</sup> and compared with those in China. In this study, mainland China was divided into four economic regions: eastern, northeast, central, and western. Gross domestic product (GDP) per capita was used to represent the economic development of a region. Population data and GDP were obtained from the official report of China (<http://www.stats.gov.cn/>).

### *Statistical analysis*

Categorical data are presented as percentages. Student's *t*-test or Mann-Whitney *U*-test was performed for comparisons of continuous variables depending on the normality of data. The  $\chi^2$  test or Fisher's exact test was performed for categorical data. The nonparametric correlation statistical test (one-sided Spearman's test) was performed to analyze the correlations between regional GDP per capita and EUS rate. Statistical analysis was performed using SPSS version 22.0 for Windows (SPSS Inc., Chicago, IL, USA). Statistical significance was set at  $P < 0.05$ .

## RESULTS

### *Hospitals, infrastructure, and endoscopists for EUS service*

From 2012 to 2019, the number of hospitals performing digestive endoscopy in mainland China increased from 6128 to 7470 (1.22-fold), and the number of hospitals performing EUS increased from 531 to 1236 (2.33-fold). In 2019, there were 333 prefecture-level divisions (administrative districts lower than provinces) in mainland China, and EUS was performed in 268 (80.5%) of them.

Most hospitals performing EUS in China were tertiary referral hospitals (89.6% in 2012 and 84.7% in 2019), and approximately half (53.1% in 2012 and 48.4% in 2019) were located in eastern China. In 2012, 386

hospitals had 741 EUS processors, whereas in 2019, 998 hospitals had 1586 EUS processors and 1911 echoendoscopes [Table 1].

In 2019, there were 39,638 endoscopists in mainland China, and 4025 (10.2%) could perform EUS. The median number of endoscopists performing EUS per hospital was 2 (range, 1–16; interquartile range [IQR], 1–4). Most endoscopists (90.9%) performing EUS were concentrated in tertiary referral hospitals [Table 1].

### EUS utilization

From 2012 to 2019, the total EUS volume in mainland China increased from 207,166 to 464,182 (2.24-fold), and the estimated EUS rate increased from 15.5 to 32.9 per 100,000 inhabitants. The EUS rates in mainland China were lower than those in developed countries. However, EUS rates in mainland China showed a higher growth rate [Figure 1]. The volume of interventional EUS increased from 10,737 in 2012 to 15,334 in 2019 (1.43-fold), but its proportion in all cases of EUS decreased from 5.18% to 3.30% [Table 2].

Figure 2 shows the EUS rates in various regions between 2012 and 2019. A substantial disparity was observed in the regional distribution of EUS utilization, but the increase in EUS rate was more apparent in the less-developed regions, including West (2.46-fold) and Central (2.31-fold). For each provincial region in China, the EUS rates had increased from 2012 to 2019. A significant correlation was observed between the EUS rate and GDP per capita in 2012 and 2019 (2012:  $r = 0.618$ ,  $P < 0.001$ ; 2019:  $r = 0.559$ ,  $P = 0.001$ ) [Figure 3].

Substantial variations were observed in the annual EUS volumes among different hospitals. In 2012, the

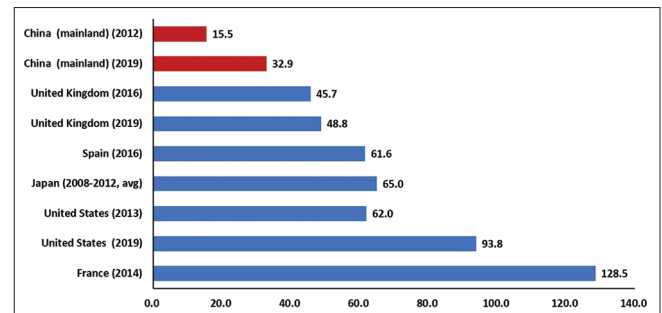
median EUS volume per hospital was 152 (range, 1–4543; IQR, 58.5–387), and 117 (22.0%) hospitals performed fewer than 50 EUS annually; in 2019, the median EUS volume decreased to 123 (range, 1–6224; IQR, 39.5–375), and 359 (29.1%) hospitals performed fewer than 50 EUS annually. In the 801 hospitals that started EUS after 2012, the median EUS volume in 2019 was 74 (range, 1–3110; IQR, 28–189). In 2019, 164 secondary referral hospitals performed 2.38% of all EUS procedures (11,029/464,182), and the median annual EUS volume was 36.5 (range, 1–661; IQR, 36.5–78.25) and 160.0 (range, 1–6244; IQR, 51.75–450.0) for secondary and tertiary referral hospitals, respectively.

### EUS-FNA quality

In 2019, the nationwide EUS-FNA-positive rate was 77.6% (data from 425 hospitals). As shown in Table 3, the EUS-FNA-positive rate was similar in hospitals with different EUS-FNA volumes and practice durations (starting EUS-FNA before or after 2012).

## DISCUSSION

To the best of our knowledge, this is the first national report of EUS in China, the largest developing country



**Figure 1.** Estimated EUS rates in China (mainland) and developed countries (per 100,000 inhabitants)

**Table 1. Number of hospitals, infrastructure, and endoscopists for EUS service in mainland China in 2012 and 2019**

	Hospital performing EUS		EUS processor		Echoendoscope	Endoscopist performing EUS
	2012, n (%)	2019, n (%)	2012, n (%)	2019, n (%)	2019, n (%)	2019, n (%)
Hospital grading						
Tertiary	476 (89.6)	1046 (84.7)	599 (80.8)	1409 (88.8)	1743 (91.2)	3657 (90.9)
Secondary	48 (9.0)	164 (13.3)	117 (15.8)	155 (9.8)	143 (7.5)	305 (7.6)
Ungraded	7 (1.3)	25 (2.0)	25 (3.4)	22 (1.4)	25 (1.3)	63 (1.6)
Hospital distribution						
Northeast	42 (7.9)	98 (7.9)	65 (8.8)	98 (6.2)	120 (6.3)	256 (6.4)
East	282 (53.1)	594 (48.1)	373 (50.3)	796 (50.2)	1007 (52.7)	2122 (52.7)
Central	97 (18.3)	275 (22.3)	140 (18.9)	353 (22.3)	377 (19.7)	842 (20.9)
West	110 (20.7)	289 (23.4)	163 (22.0)	339 (21.4)	407 (21.3)	805 (20.0)
Total	531 (100)	1235 (100.0)	741 (100)	1586 (100)	1911 (100)	4025 (100.0)

in the world, and shows that EUS utilization has considerably improved from 2012 to 2019.

EUS utilization requires improved infrastructure and skilled endoscopists than esophagogastroduodenoscopy or colonoscopy. In developed countries, EUS is a well-established technique. Several national surveys have recently shown evident improvements in EUS in developed countries.<sup>[3-5,8-11]</sup> However, there is a considerable shortage of EUS services in many developing countries.<sup>[12-14]</sup> In a survey of endoscopists

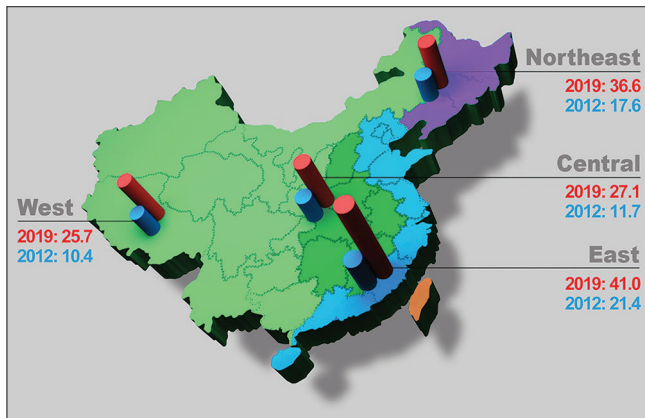
from South and Southeast Asia, equipment cost and the lack of endoscopists performing EUS were identified as the primary obstacles for the development of this technique.<sup>[12]</sup> EUS is also a relatively new and rising technique in mainland China. In 2012, only

**Table 2. Volume of EUS in 2012 and 2019 in mainland China**

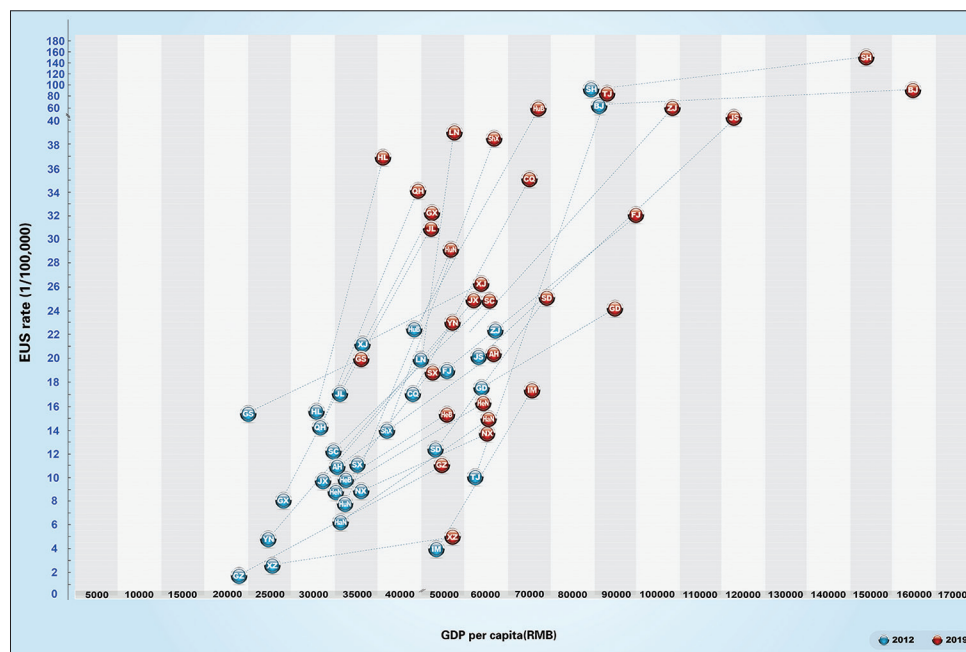
	2012, n (%)	2019, n (%)
Diagnostic EUS without FNA	196,429 (94.8)	448,848 (96.7)
Gastrointestinal tract	-	381,499 (82.2)
Biliary tract and pancreas	-	67,349 (14.5)
Interventional EUS	10,737 (5.2)	15,334 (3.3)
Total	207,166 (100.0)	464,182 (100.0)

**Table 3. EUS-FNA-positive rate of hospitals with different volume and practice duration in mainland China in 2019**

	Number of hospitals	EUS-FNA positive rate	P
EUS-FNA volume in 2019			
≥50	68	79.9% (8357/10,463)	0.704
<50	357	71.6% (2936/4099)	
The year starting EUS-FNA			
Before 2012	252	78.7% (9362/11,902)	0.565
After 2012	173	72.6% (1931/2660)	
Total	425	77.6% (11,293/14,562)	



**Figure 2.** Development of EUS rate (number of EUS per 100,000 inhabitants in a year) in 4 economic regions of mainland China between 2012 and 2019 (This map does not show the complete territory of China)



**Figure 3.** Scatter plot depicting the correlation between EUS rate and GDP per capita in 31 provincial regions of mainland China in 2012 and 2019 (blue points, 2012:  $r = 0.618$ ,  $P < 0.001$ ; red points, 2019:  $r = 0.559$ ,  $P = 0.001$ ). Both x- and y-axes of the graph have a different scale after the breaks (/ and \). AH: Anhui; BJ: Beijing; CQ: Chongqing; FJ: Fujian; GS: Gansu; GD: Guangdong; GX: Guangxi; GZ: Guizhou; IM: Inner Mongolia; HaN: Hainan; HeB: Hebei; HL: Heilongjiang; HeN: Henan; HuB: Hubei; HuN: Hunan; JS: Jiangsu; JX: Jiangxi; JL: Jilin; LN: Liaoning; NX: Ningxia; QH: Qinghai; SD: Shandong; SH: Shanghai; ShX: Shaanxi; SX: Shanxi; SC: Sichuan; TJ: Tianjin; XZ: Tibet; XJ: Xinjiang; YN: Yunnan; ZJ: Zhejiang; GDP, gross domestic product



531 hospitals performed EUS in mainland China. As China's economy thrives, an increasing number of hospitals have purchased EUS equipment and trained their endoscopists. For example, the number of EUS processors increased from 741 to 1586 (2.14-fold) over 7 years. In 2019, the number of hospitals performing EUS increased by 2.33-fold, and the total EUS volume increased by 2.24-fold. Although the EUS rate is currently lower than that in developed countries, the gap is narrowing. We believe that this trend will extend to other economically thriving, developing countries.

Despite increasing availability, EUS in China is still at an early stage of development. First, EUS requires substantial improvement in less-developed regions. In 2019, the most developed regions in China, Shanghai and Beijing, had a EUS rate of 152.0 and 93.7 per 100,000 inhabitants, respectively; these EUS rates were comparable to those of developed countries. Conversely, the EUS rate in Tibet was only 4.9 per 1,000,000 inhabitants. In 2019, EUS could not be performed in 19.5% of prefecture-level divisions, most of which are located in the western region. As shown in this study, the EUS rate in a region was significantly positively associated with the GDP per capita ( $P < 0.05$ ). Therefore, the gap in EUS rate between the different regions will be unavoidable in a certain period. However, the increase in EUS rates in the less-developed western (2.46-fold) and central (2.31-fold) regions is encouraging and indicates that the EUS shortage would be alleviated in the following years. A disparity in EUS rates exists among different regions in developed countries as well. In a study from Ontario, Canada, the EUS rate of the southwest region in 2011 was over 4 times greater than that of the northwest region (61.6 vs. 12.9 per 100,000 inhabitants).<sup>[15]</sup> Another study from the United States also found this significant disparity in EUS rates among geographic areas.<sup>[16]</sup> Such disparity is unlikely to be solved within a short time. However, since EUS is mainly a diagnostic tool and not for emergency use, we suggest establishing a referral system for EUS services and promoting multisite practice by EUS practitioners so as to warrant the accessibility of EUS for residents in less-developed areas.

Second, the proportion of interventional EUS was low. EUS-guided sampling and therapy are the advantages of this technique. After 2010, the proportion of EUS-FNA has increased to 17%–40% in developed

countries.<sup>[5,15,17-19]</sup> In our study, the volume of interventional EUS increased from 10,737 in 2012 to 15,334 in 2019, but its proportion decreased from 5.18% to 3.30%. Moreover, less than 20% of EUS examinations were indicated for the biliary tract and pancreas in 2019, which was lower than the percentages in developed countries. The lower proportion of interventional and pancreatobiliary EUS may be attributed to the considerable number of hospitals and practitioners that newly started EUS. Pancreatobiliary scanning and FNA are more technique demanding and pose higher risk than gastrointestinal tract scanning. Therefore, endoscopists typically start EUS practice with subepithelial lesions investigation and gastrointestinal cancer staging. In other words, the value of EUS has not yet been maximized in China, and such gap may be fulfilled by further training and experience accumulation of EUS practitioners.

Third, hospitals with a low EUS volume covered a considerable proportion of cases. In 2019, the median EUS volume per hospital was 123 (IQR, 39.5–375), and, for the 801 newcomers starting EUS after 2012, the median volume was only 74 (IQR, 28–189), which was much lower than the volume of Spain (median volume: 450) and Portugal (average volume: 499.2).<sup>[5,18]</sup> The influence of volume on the quality of endoscopy is a concern, and prospective studies have shown that the quality of ERCP is lower in low-volume hospitals or endoscopists.<sup>[20,21]</sup> Several studies have shown that low volume is a potential risk factor for adverse events of EUS-FNA,<sup>[22,23]</sup> but not for the EUS-FNA–positive rate for pancreatic lesions.<sup>[24]</sup> In our study, the EUS-FNA–positive rate was similar in hospitals with different EUS-FNA volumes and practice durations. According to Savides *et al.*,<sup>[24]</sup> it is possible that endoscopists with fewer volumes tend to select patients with a high possibility of malignancy and lesions for easy biopsy. Overall, these emerging EUS providers had a relatively low volume with an acceptable EUS-FNA–positive rate and may serve as a promising approach to meet the large demand in China.

Several limitations exist in this study. First, due to the retrospective design, recall bias could not be avoided. A national prospective registry would be necessary for subsequent studies. Second, because the surveys were not specifically designed for EUS, the data did not include the details on infrastructure, indication, sedation, availability of rapid on-site evaluation, and complications of EUS. Therefore, we could not

perform a multivariable regression for the EUS-FNA-positive rate. These issues will be investigated in future studies. Finally, the EUS rates of developed countries were estimated from studies with different designs and coverage, and there was variance in the indication, specific technique, and population structure among these countries. Therefore, the comparison of EUS rates just drew an outline.

In conclusion, EUS is at an early but inspiring developmental stage in China. Although most hospitals have low annual volumes, the hospitals that have started EUS after 2012 will be the essential growth point for EUS development in China.

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Nil.

### Conflicts of interest

Zhen-Dong Jin is an Associate Editor of the journal and Zhao-Shen Li is an Honorary Editor-in-Chief. This article was subject to the journal's standard procedures, with peer review handled independently of the editors and their research groups.

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