



## A review of general surgery resident experience in common bile duct exploration in the ERCP era

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### ABSTRACT

**Background:** Use of minimally invasive techniques for management of common bile duct (CBD) stones has led to declining number of CBD explorations (CBDE) performed at teaching and non-teaching institutions. We evaluate the impact of this decline on surgery training in bile duct procedures.

**Study design:** National operative data for general surgery residents (GSR) were examined from 2000 to 2018. Biliary operations including, cholecystectomy open and laparoscopic, and CBDE open and laparoscopic were evaluated for mean number of cases per graduating GSR.

**Results:** Despite increases in number of GSR, case numbers for laparoscopic cholecystectomy increased 39% from 84 to 117,  $p < .00001$ , per GSR. Mean number of cases for open CBDE, however, decreased 74% from 2.7 to 0.7,  $p < .00001$ , per GSR and laparoscopic CBDE declined 22% from 0.9 to 0.7 per resident. **Conclusion:** GSR operative case volume in CBDE has declined significantly creating a training deficiency for this complex skill. Novel simulation, including fresh cadavers, may offer the best option with high-fidelity, dynamic training to mitigate the loss of low volume, high acuity procedures.

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### Introduction

More than 27,000 patients are admitted to the hospital yearly with the diagnosis of choledocholithiasis in the United States.<sup>1</sup> Despite this frequent reason for hospitalization, the optimal management strategy for common bile duct (CBD) stones continues to be controversial. Historically, surgical common bile duct exploration (CBDE) was performed for stone clearance. With the advent of advanced technology, such as endoscopic retrograde cholangiopancreatography (ERCP), a paradigm shift has occurred leading to increasing use of minimally invasive methods for CBD clearance.<sup>1</sup> An estimated 450,000 ERCPs are performed nationwide each year, and this number is likely to increase as more advanced endoscopists are trained.<sup>2</sup> Over the last 20 years, there has been a significant increase in the number of hospitalized patients with gallstones who underwent ERCP and cholecystectomy during admission.<sup>3</sup> Approximately 2/3 of these ERCPs were performed

within 1 day of cholecystectomy.<sup>3</sup> In parallel, the number of diagnostic only ERCPs performed nationwide has declined.<sup>3</sup> Of the approximately 35,000 inpatient “therapeutic” ERCPs performed yearly, the most common procedures are sphincterotomy (43%) and CBD stone clearance (29%).<sup>4,5</sup> Subsequently, the number of common bile duct explorations (CBDE) performed nationwide has declined. In a 15 year period from 1998 to 2013 CBDE (both open and laparoscopic) dramatically dropped from 40% of those admitted to just 8.5%.<sup>1</sup>

As decreasing numbers of CBDE are being performed the rates of technical complications related to the procedure are rising.<sup>6</sup> A national decrease in experience with CBDE is likely the primary driving factor for this increase.<sup>6</sup> Inexperienced surgeons have been shown to have a significantly higher rate of bile leak and longer operative times when performing bile duct explorations.<sup>7,8</sup> Given that surgical volume is related to operative complications and less CBDE are being performed nationally, complication rates are likely to continue to increase without a training solution.<sup>9</sup> A steady decline in the overall number of CBDE occurred between the years 1997–2007 with cases dropping from 250,000 nationally to just 9,000. Despite this decline nearly 60% of the procedures performed today occur at non-teaching hospitals indicating that it continues to be an important surgical skill for a general surgeon to possess.<sup>10</sup>

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The Accreditation Council for Graduate Medical Education (ACGME) Residency Review Committee (RRC) for Surgery has set the minimum required number of biliary cases at 85 for graduating general surgery residents (GSR) however, there is no minimum number of CBD procedures required for GSR prior to completion of training.<sup>11</sup> With the majority of CBDE cases being performed at non-teaching institutions as well as evidence that laparoscopic cholecystectomy (LC) with CBDE is highly effective in detecting and removing CBD stones and is equivalent in cost and patient acceptance to LC plus ERCP, it is imperative for the general surgeon to be proficient in performing these biliary procedures.<sup>12</sup> Given that ERCP and other minimally invasive methods may not always be readily available, the graduating GSR still requires a mastery of operating on the common bile duct.

The purpose of this study is to evaluate the effect of this paradigm shift towards endoscopic management of choledocholithiasis and subsequent decline in common bile duct explorations on current GSR operative case volume in biliary procedures. Additionally, we aim to identify solutions to train residents in a complex skill despite low operative volume.

## Methods

Case log graduate statistics National Reports from the RRC for Surgery were examined from 2000–2018.<sup>10</sup> National Resident Average (MEAN) cases performed as SURGEON CHIEF, SURGEON JUNIOR and SURGEON TOTAL were reviewed for: total biliary operations, open and laparoscopic cholecystectomy, open and laparoscopic common bile duct exploration, and choledochoenteric anastomosis. SURGEON TOTAL includes all cases logged as SURGEON CHIEF plus SURGEON JUNIOR by GSR over the residency period. SURGEON CHIEF cases represent those logged during the final year of training, and SURGEON JUNIOR cases represent those in the preceding years. Number of GSR programs and graduating chief GSR were also examined.

### Statistical analysis

Analysis of variance, where case volume (average per graduating GSR) was the outcome and year was the main effect, were performed. Data were reported as average values  $\pm$  standard deviation (SD) for each year. Tukey post-hoc testing was performed to confirm differences between groups. Statistical significance was accepted at  $p < .05$  level.

## Results

From 1999 to 2000 to 2017–2018 there was a 21% increase in graduating GSR (989 vs 1198). Despite this increase, GSR completed training with a 21% increase in the average number of biliary procedures performed (Table 1). This was largely driven by a 39% increase in average case volume of laparoscopic cholecystectomies performed by GSR throughout their years in residency training

(1999-00:  $84 \pm 36$  vs 2017-18:  $117 \pm 39$ ;  $p < 0.0001$ ). The number of open cholecystectomies performed by graduating GSR, however, declined by 46% (1999-00:  $15.5 \pm 8$  vs 2017-18:  $8.3 \pm 6$ ;  $p < 0.0001$ ) over the same time period (Table 1). From 2004 to 05 through 2008-09, cholecystectomies were reported as total numbers and not subdivided as laparoscopic or open. As such, there is missing data in this series (Fig. 1).

Average case volume in bile duct surgery for GSR completing their training also declined from 1999 to 2000 through 2017–2018. Average GSR case volume for both open and laparoscopic CBDE decreased 74% (1999-00:  $2.7 \pm 2$  vs 2017-18:  $0.7 \pm 1$ ;  $p < .0001$ ) and 22% (1999-00:  $0.9 \pm 2$  vs 2017-18:  $0.7 \pm 2$ ;  $p = \text{NS}$ ) respectively (Table 2; Fig. 2). When examining case experience by resident level, case volume in both open and laparoscopic CBDE declined amongst both SURGEON JUNIOR and SURGEON CHIEF GSR during the study period almost to the point of non-existent (Table 2; Fig. 3).

Additional information regarding GSR case volume with choledochoenteric anastomosis was reviewed. There was a 50% decline ( $3.0\text{--}1.5$ ;  $p < .00001$ ) in the average number of choledochoenteric anastomosis cases performed for GSR (Table 2). There was a 55% decrease for CHIEF and 42% decrease for JUNIOR GSR case volume in choledochoenteric anastomosis over the study period (Table 2).

## Discussion

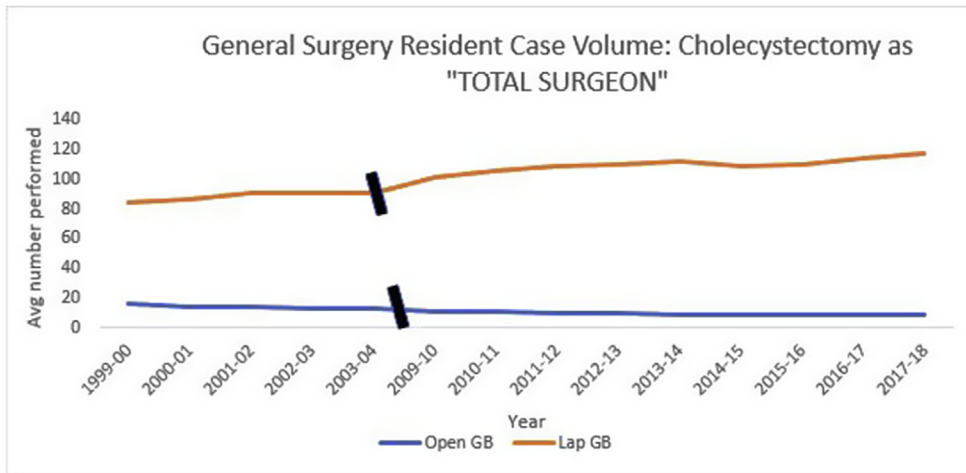
This review of GSR national operative logs shows that the overall decline in CBDE nationwide over the past two decades<sup>1</sup> is mirrored with a decline in exposure to these procedures in training. Decreasing opportunities to master this complex procedure has led to inadequate training in a skill that needs to remain in the general surgeon's armamentarium. Over the last 2 decades there has been an obvious paradigm shift in the management of choledocholithiasis. In 2013 upwards of 70,000 ERCPs were performed nationally with over 35,000 of these being classified as "therapeutic".<sup>4</sup> During this time period total use of ERCP for management of choledocholithiasis increased from 16 per 100,000 to 22 per 100,000.<sup>4</sup> In addition, in the decade from 2002 to 2013 there was a significant increase in the percentage of ERCPs being performed for the purpose of biliary stone removal from 25% to 32% ( $p < 0.001$ ).<sup>5</sup> This shift in management is mirrored with our findings of a decline in CBDE experience during general surgery training. As more physicians turn to ERCP for bile duct clearance, the availability of operative cases for surgical duct clearance is decreasing.

In a study performed by Baucom et al. 86% of general surgeons reported that their preferred method for management of common duct stones was with a pre-operative ERCP.<sup>13</sup> Non-metropolitan surgeons were significantly less likely to choose this approach. Of these respondents, who identify themselves as general surgeons, 42% cited a major barrier to performing CBDE was lack of comfort with the procedure with 20% reporting to never have performed a single open or laparoscopic CBDE before.<sup>13</sup> The results of our study echo this lack of training experience in biliary procedures with graduating chief GSR performing an average of less than 1 CBDE by

**Table 1**  
General surgery resident case volume: Gallbladder procedures.

GSR Training/Procedures	1999–2000	2017–2018	Change	P-value
GSR Training Programs in US	N = 252	N = 251	–0.4%	NA
Graduating GSR	N = 989	N = 1198	21%	NA
Total Biliary Procedures	Avg. = $107 \pm 36$ (SD)	Avg. = $129.5 \pm 39$ (SD)	21%	<0.0001
Open Cholecystectomy	Avg. = $15.5 \pm 8$ (SD)	Avg. = $8.3 \pm 6$ (SD)	–46%	<0.0001
Laparoscopic Cholecystectomy	Avg. = $84 \pm 36$ (SD)	Avg. = $117 \pm 39$ (SD)	39%	<0.0001

Table 1. Change in general surgery resident case volume (average  $\pm$  standard deviation) in gallbladder procedures from 1999 to 2000 to 2017–2018. Reported as total cases GSR = General Surgery Resident; Avg = average; NA = not applicable.



**Fig. 1.** General Surgery Resident Case Volume: Gallbladder Surgery for graduating GSR from 1999 to 00 through 2017-18. From 2004 to 05 through 2008-09, only total number of cholecystectomies were reported. As such, there is missing years of data. = years with missing data.

**Table 2**  
General surgery resident case volume: Bile duct procedures.

Procedure	1999–2000 (Avg. ± SD)	2017–2018 (Avg. ± SD)	Change	P-value
CBDE TOTAL	2.7 ± 2	0.7 ± 1	–74%	<0.0001
CBDE CHIEF	1.1 ± 1	0.3 ± 1	–73%	<0.0001
CBDE JR	1.5 ± 2	0.4 ± 1	–73%	<0.0001
LCBDE TOTAL	0.9 ± 2	0.7 ± 2	–22%	NS
LCBDE CHIEF	0.3 ± 1	0.3 ± 1	NC	NS
LCBDE JR	0.5 ± 1	0.4 ± 1	–20%	0.02
CDE Anastomosis TOTAL	3 ± 3	1.5 ± 2	–50%	<0.0001
CDE Anastomosis CHIEF	1.8 ± 2	0.8 ± 1	–55%	<0.0001
CDE Anastomosis JR	1.2 ± 2	0.7 ± 1	–42%	<0.0001

**Table 2.** Change in general surgery resident case volume (average ± standard deviation) in bile duct procedures from 1999 to 2000 to 2000–2018 by TOTAL, CHIEF, JUNIOR GSR. CBDE = open CBDE; LCBDE = Laparoscopic CBDE; CDE = choledochoenteric; JR = Junior; Avg = average; SD = Standard Deviation; NS = not significant.

the time their training is complete.

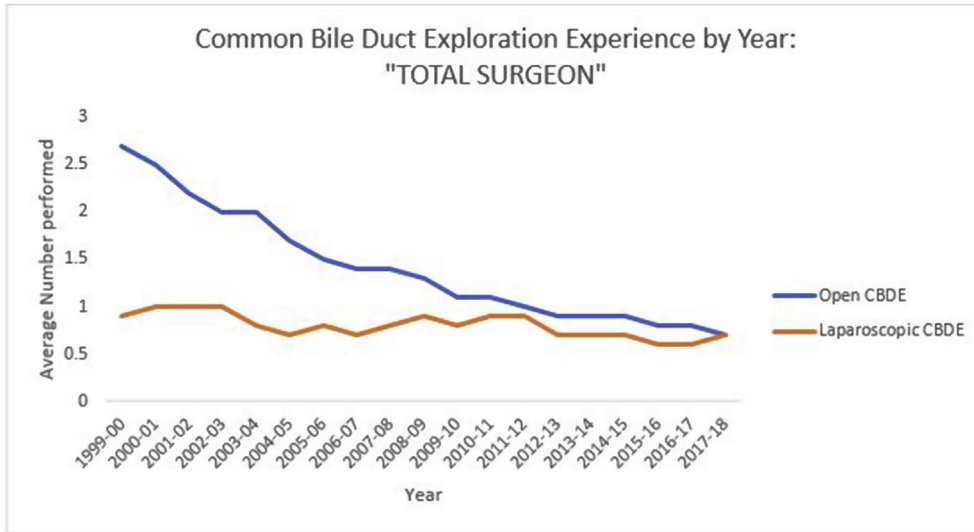
Although average number of open cholecystectomies performed by trainees decreased 46% during the study period, overall biliary surgery numbers increased 21%. This rise in cholecystectomy numbers occurred with a concurrent 21% increase in number of graduating residents. A significant 39% rise in number of laparoscopic cholecystectomies performed per resident appears to be the driving force behind the consistent increase in biliary surgery numbers over the last 2 decades. In contrast to the increase in laparoscopic cholecystectomies, laparoscopic common bile duct exploration numbers did not rise similarly. Increases in laparoscopic cholecystectomy have not translated to increases in laparoscopic CBDE. These numbers, conversely, have remained very low with a non-significant decline throughout the study period. This highlights the fact that this procedure is not and traditionally has not been a part of general surgery training. In light of increasing evidence that single stage laparoscopic cholecystectomy and laparoscopic CBDE is safe, effective and in some cases preferable to a two stage approach to CBD stone clearance, it is becoming more important to train general surgery residents in this skill.<sup>12,14</sup> Regardless of the significant increase in number of total cholecystectomies being performed by graduating general surgery trainees, bile duct surgeries performed by GSR in training have steadily declined over the last 20 years.

In addition to a decline in CBDE, general surgery trainees are performing less overall bile duct surgery including choledochoenteric anastomoses which decreased 50% from 2000 to 2018. While this decline may not be directly linked to an increase in ERCP use for bile duct clearance it further elucidates the general surgery

trainee’s unfamiliarity with bile duct surgery. Given that choledochoenteric anastomosis may be required when duct clearance fails or in the case of a bile duct injury this is also an important skill for the graduating general surgeon to possess. The reason behind this downtrend is unclear but may be related to resident work hour restrictions, the growth of hepatobiliary fellowships or the trend towards sending complex biliary reconstructions to high-volume centers.<sup>15</sup>

Results of the certifying examination highlight most trainees’ lack of comfort in this area. Examinees have shown reluctance to choose CBDE as a treatment during examination and score poorly on principles of duct exploration.<sup>16</sup> Moreover, when senior residents are asked what they would ask a senior colleague for help with, bile duct surgery is a common answer, likely due to limited experience and lack of confidence in the procedure.<sup>17</sup> This is not surprising given that today’s graduating residents will likely have little to no operative experience with CBDE prior to residency graduation.

Despite decreasing case volumes and experience, the graduating general surgery resident must be proficient in common bile duct exploration. CBDE continues to be a skill that is imperative for the general surgeon to possess. Many surgical trainees go on to practice in community settings where advanced ERCP may not be readily available or may require transfer to another facility. Even with the decline in CBDE numbers, there remains a significant amount of these cases being performed at non-teaching hospitals.<sup>10</sup> With 60% of these cases occurring at non-teaching institutions yearly there is a continued need for the general surgeon to be proficient at the skill.<sup>10</sup> Additionally, recent evidence has shown that single stage

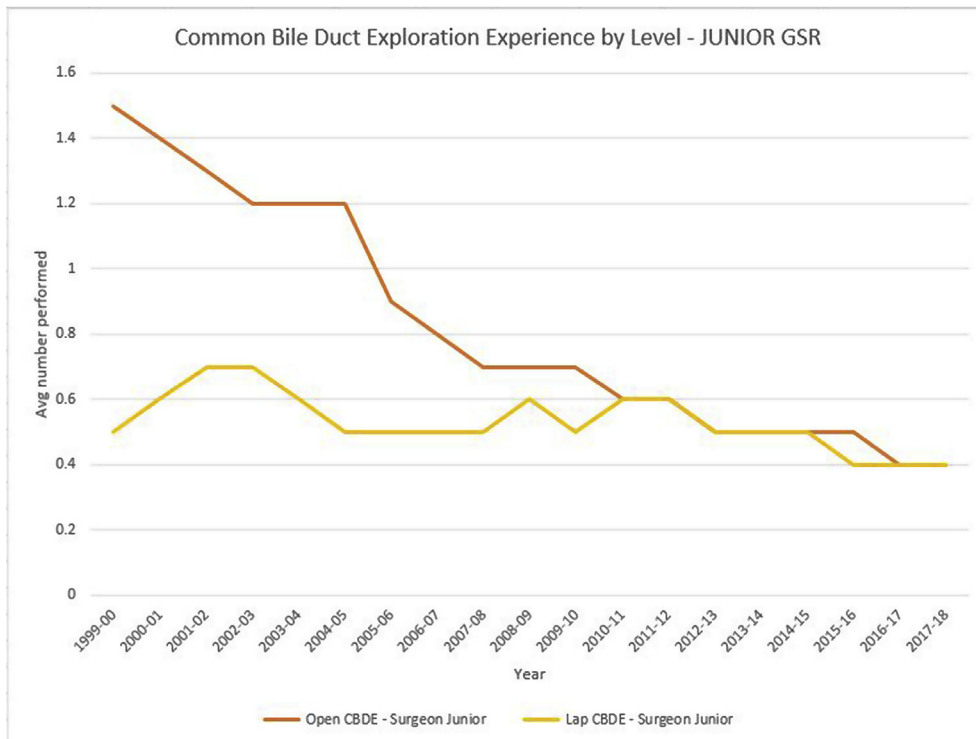


**Fig. 2.** Average Common Bile Duct Explorations for Graduating GSR from 1999 to 00 to 2017-18 for open and laparoscopic common bile duct explorations. CBDE = Common Bile Duct Explorations.

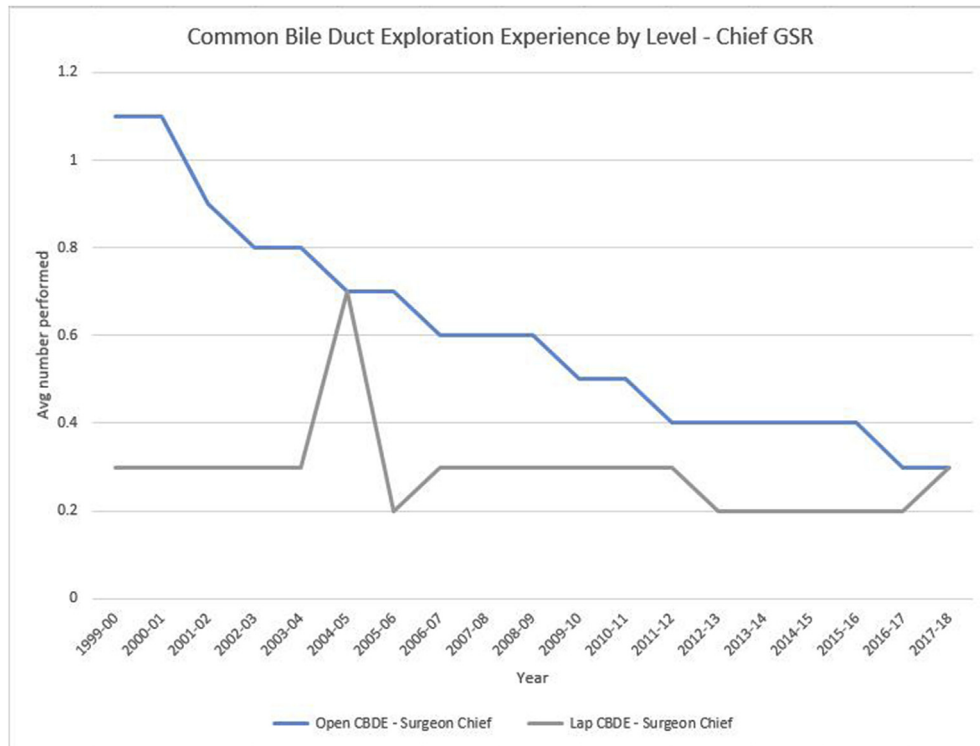
management of common duct stones with laparoscopic CBDE and laparoscopic cholecystectomy under one anesthesia has decreased hospital length of stay, decreased healthcare costs and equivalent outcomes to a two staged procedure with pre or post-operative ERCP and cholecystectomy.<sup>17,18</sup> This evidence incentivizes the general surgeon to master the skill for improved patient outcomes.

Declining case volumes matched with a continued need for exposure has led to a complex problem of how to adequately train the general surgery resident to be proficient and comfortable with bile duct surgeries. Surgical simulation has come to the forefront as

a mode of development of critical technical skills prior to operating room experience. It has the advantage of providing directed practice in an environment that is safe and tolerant of failure. The use of fresh tissue simulation in the form of human cadavers can fill the CBDE training void created by low case volumes. Our institution utilizes a training program built around fresh, perfused cadavers to teach and refine surgical skills. This model allows for surgical skills practice that models both the anatomical and physiological environments that the trainee may face in real life operative situations. With the use of perfused cadaver training the resident receives



**Fig. 3a.** Average Common Bile Duct Explorations for Graduating GSR by Level – Surgeon Junior from 1999 to 00 to 2017-18 for open and laparoscopic common bile duct explorations. CBDE = Common Bile Duct Explorations; lap = laparoscopic.



**Fig. 3b.** Average Common Bile Duct Explorations for Graduating GSR by Level – Surgeon Chief from 1999 to 00 to 2017–18 for open and laparoscopic common bile duct explorations. CBDE = Common Bile Duct Explorations; lap = laparoscopic.

both tactile and visual feedback while learning to master complex but rarely seen surgical skills such as CBDE. Application of this high-fidelity training module is a viable solution to alleviate the skills deficit caused by declining case numbers and ensure that surgical trainees obtain the comfort level needed to safely perform CBDE once their training is complete. Future directions of surgical simulation with human cadavers may include initial training in rarely performed procedures in teaching institutions such as CBDE as well as skills refresher courses. In addition, maintenance of skills and certification programs may consider the use of cadaver simulation to test and measure competency.

With strong evidence of a training void in CBDE and continued need for competence amongst surgeons in the procedure the question of training requirements and case minima arises. The ACGME case minima were not set in place to measure or ensure competency but rather to judge that a teaching institution provides adequate breadth of surgical experience.<sup>19</sup> With evidence of decreasing GSR experience and no minimum case requirement for bile duct surgery during GSR, we must rely on innovative training methods such as fresh tissue simulation programs to ensure that graduating chief resident are comfortable and adequately prepared to perform CBDE when the need arises.

There are several limitations of this study including that the data is administrative data which may lead to a misclassification bias. In addition case logs are self-reported by residents and as such there is a possibility of incorrect coding of case logs which could lead to erroneous reporting. Lastly, the ACGME data is pooled nationwide data and there may be high inter-institutional variability.

## Conclusion

Over the last two decades a paradigm shift in the management of choledocholithiasis has led to a precipitous decline of exposure

to bile duct surgery, specifically common bile duct exploration, for the general surgery trainee. This skill remains imperative to today's general surgeon and must continue to be taught and mastered despite decreasing case volume. Novel simulation models, including fresh cadavers, may offer the best option with high-fidelity, dynamic training to mitigate the loss of these low volume, high acuity procedures.

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