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*Retrospective Cohort Study*

**ERCP-related early perforations: A study of effects of procedure duration, complexity, and endoscopist experience**

ERCP-related early perforations

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**Abstract**

BACKGROUND

Perforations during ERCP are rare (<1%) but potentially fatal events (up to 20% mortality). Given its rarity, most data is through case series studies from centers or analysis of large databases. Although a meta-analysis has shown fewer adverse events as a composite (bleeding, pancreatitis, perforation) during ERCP performed at high-volume centers, there is very little real-world data on endoscopist and center procedural volumes, ERCP duration and complexity on the occurrence of perforation.

AIM

We aimed to study the profile of perforations related to ERCP by center and endoscopist procedure volume, ERCP time, and complexity from a national endoscopic repository.

METHODS

Patients from Clinical Outcome Research Initiative National Endoscopic Database  
CORI-NED

(2000-2012) who underwent ERCP were stratified based on the endoscopist and center volume (quartiles), and total procedure duration and complexity grade of the ERCP based on procedure details. The effects of these variables on the perforations that occurred were studied. Continuous variables were compared between perforations (Perf) and no perforations (NoPerf) using the Mann-Whitney U test as the data demonstrated significant skewness and Kurtosis.

## RESULTS

A total of 14,153 ERCPs were performed by 258 endoscopists, with 20 reported perforations (0.14%) among 16 endoscopists. Mean patient age in years ( $\pm$ SD)  $61.6 \pm 14.8$  vs  $58.1 \pm 18.8$  (Perf vs. NoPerf,  $p$ =NS). The cannulation rate was 100% and 91.5% for Perf and NoPerf groups, respectively. 13/20 (65%) of endoscopists were high-volume performers in the 4<sup>th</sup> quartile, and 11/20 (55%) of perforations occurred in centers with the highest volumes (4<sup>th</sup> quartile). Total procedure duration in minutes was  $60.1 \pm 29.9$  vs.  $40.33 \pm 23.5$  (Perf vs. NoPerf,  $p < 0.001$ ). Fluoroscopy duration in minutes was  $3.3 \pm 2.3$  vs.  $3.3 \pm 2.6$  (Perf vs. NoPerf  $p$ =NS). 50% of the procedures were complex and greater than grade 1 difficulty. 3/20 (15%) patients had prior biliary surgery. 13/20 (65%) had sphincterotomies performed with stent insertion. Peritonitis occurred in only 1/20 (0.5%).

## CONCLUSION

Overall adverse events as a composite during ERCP are known to occur at a lower rate with higher volume endoscopists and centers. However, perforations studied from the national database show prolonged and more complex procedures performed by high-volume endoscopists at high-volume centers contribute to perforations.

**Key Words:** Endoscopic retrograde cholangiopancreatography; ERCP; endoscopy complications; perforations

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**Core tip:**

We analyzed the profile of perforations related to ERCP from the CORI-NED database over 12 years. The retrospective analysis of 14153 ERCPs done by 258 endoscopists reported had a perforation rate of 0.14% (20 perforations) among 16 endoscopists. The cannulation rate was 100% for perforation and 91.5% for no perforation groups. 65% of endoscopists were high-volume performers, and 55% of perforations occurred in centers with the highest volumes (4th quartile). Higher volume endoscopists and centres are known to have less ERCP-related adverse events. However, this national database study on perforations has shown prolonged and complex procedures performed by high-volume endoscopists at high-volume centers contributed to perforations.

**ERCP-related early perforations: A study of effects of procedure duration, complexity and endoscopist experience**

Introduction

The indications for therapeutic ERCP have increased exponentially over the last decade [1]. Consequently, the complexity of procedures has also increased along with the training required to achieve competencies to perform such high-risk procedures. As a result, the completion success and complication rates vary widely and appear related to the endoscopist volume [2, 3].

Although perforation during ERCP is uncommon (1%), it can be fatal with up to 20% mortality [4, 5]. Most data about ERCP-related perforations is from case series or analysis of large databases. While a meta-analysis revealed lesser adverse overall events (bleeding, perforation, pancreatitis) during ERCP performed at high-volume centres [6], there is a lack of real-world data regarding endoscopist and centre procedural volumes, ERCP duration, and complexity on the occurrence of early perforations [5, 7, 8].

We analyzed a national endoscopic repository NIH-CORI-NED (National Institute of Health- Clinical Outcomes Research Initiative-National Endoscopic Database) to study the profile of perforations related to ERCP by center and endoscopist procedure volume, ERCP time, and complexity.

## Methods

### *Database*

CORI-NED is a large prospectively accrued population-based database maintained by NIH. <sup>1</sup> CORI was established in 1995 to study the use and outcomes of endoscopy in diverse gastroenterology practice settings in the United States [9]. Participating physicians are provided with an electronic health record completed at the endoscopy time and generate procedure reports. Once submitted, the report cannot be altered. Users are required to document at least 95% of the procedures in CORI. A limited dataset from every report is sent to NIH, where it is quality tested and compiled into CORI-NED. Anonymized data is collected and stored per strict HIPAA standards, and users must obtain data user agreements and IRB approval. This study was IRB-approved [1692454-2]. As CORI-NED contains information generated at the time of

ERCP, we examined early perforations discovered before the procedure report was generated, signed off, and submitted to the repository.

#### *Study Cohort, Design & Statistical Analysis*

Our study is a retrospective population-based analysis of early perforations related to ERCP. Patients over 18 years of age who underwent ERCP from 2000-2012 were studied. Data collected included age, sex, center volume, endoscopist volume, ERCP and fluoroscopy duration, indication, ERCP difficulty, prior biliary surgery dilation of strictures, sphincterotomy, sphincterotomy device used, stent placement, peritonitis. Patients were stratified based on the endoscopist's and center's volume (quartiles), total procedure duration, and complexity grade of the ERCP based on procedure details. We aim to identify age factor, ERCP fluoroscopy time, and total procedure time between patients who suffered perforation versus those who did not in the immediate post-procedural period (before the procedure note is uploaded as per CORI-NED).

The effects of these variables on the perforations that occurred were studied. In addition, continuous variables were compared between perforations (Perf) and no perforations (NoPerf) using the Mann-Whitney U test, as the data demonstrated significant skewness and Kurtosis. All analysis was performed using SPSS (v28.0). The statistical review of the study was performed by a biomedical statistician. The grades of ERCP difficulty were defined by the grading system (Supplementary Table 1) proposed by Schultz et al. and were widely used during data collection [10, 11].

#### Results

14,153 ERCPs performed by 258 endoscopists at 48 facilities were analyzed. 20 perforations (0.14%) were reported among 16 endoscopists. The mean patient age ( $\pm$  SD) was  $61.6 \pm 14.8$  vs  $58.1 \pm 18.8$  years (Perf vs. NoPerf,  $p = \text{NS}$ , Figure 1a). The cannulation rate for perforations vs no perforations was 100% and 91.5%, respectively. 11/20 (55%) of perforations happened in the centres with the greatest volumes (4th quartile), while 13/20 (65%) of endoscopists were high-volume achievers.

Total procedure duration was  $60.1 \pm 29.9$  vs.  $40.33 \pm 23.5$  minutes (Perf vs. NoPerf,  $p < 0.001$ , Figure 1b). Fluoroscopy duration was  $3.3 \pm 2.3$  vs.  $3.3 \pm 2.6$  minutes (Perf vs. NoPerf  $p = \text{NS}$ , Figure 1c). To evaluate the differences between patients who perforated versus those who did not <sup>4</sup> Mann-Whitney U Test was utilized. The test revealed a significant difference in total procedural time between those who suffered perforation versus those who did not (Median 51 vs. 32 min,  $n = 20$  vs.  $n = 14133$ ),  $U = 8467$  vs. 5816,  $z = 3.536$ ,  $p < 0.001$ ,  $r = 118$  (large effect size). Hence  $H_0$  was rejected. However, age and fluoroscopy time did not differ between the groups.

Half of the procedures were complex and more than grade 1 difficulty (Table 1). 3 out of 20 (15%) patients had prior biliary surgery. 13 out of 20 cases (65%) had sphincterotomies with stent insertion. 1 case (0.5%) had peritonitis (Table 1).

We also performed a multivariate regression analysis of age category, endoscopist ERCP volume quartile, fluoroscopy time, and total procedure time (Table 2). The regression analysis results demonstrate that only prolonged total procedural time among the parameters studied is associated with perforations (HR 1.022, 95% CI 1.001-1.043,  $p < 0.036$ ).

## Discussion

Our nationwide population-based study about ERCP identified several factors related to procedure complexity, center, and endoscopist performance as significant risk factors for ERCP-related perforations. The risk factors for ERCP-related perforations were a higher grade of complexity requiring a longer duration of the procedure, a high-volume center, and a high-volume endoscopist.

Overall, greater volume endoscopists and centres are reported to have a reduced rate of adverse events during ERCP [6]. Currently, there is a lack of consensus on the minimum required volume to maintain ERCP competency. The minimum standards and mandatory curriculum required for an endoscopist and center to maintain ERCP skills have been recently defined in a multicenter clinical trial but have not been widely adopted [12]. Short-term ERCP complications occur in about 10% of patients, including

cholangitis, pancreatitis, bleeding, and perforation [13]. It has also been suggested that ERCP-related complications, especially perforations, tend to occur more frequently in lower-volume centers by and with lower endoscopist volume by quartiles [5, 6]. An analysis of the Swedish National Register for Gallstone Surgery and ERCP (GallRiks) [14] has also shown that higher endoscopist and center case volumes are associated with safer ERCP, similar to our results. However, this study analyzed only ERCP for stones and malignancy as an indication of ERCP. They found that higher case and center volume correlated with lower complication rates and shorter procedure time in ERCP for CBD stones. Conversely, factors associated with perforation in our study were the prolonged duration of the procedure, as shown previously by other studies [5, 15, 16]. A large review of 142,847 ERCPs found a 0.39% perforation rate, where sphincterotomy was responsible for 41% of perforations [17]. Interestingly, in our study, ERCP with perforation had a 100% cannulation rate compared to 91.5% in ERCP with no perforation. Also, 50% of the perforations occurred in complex ERCPs (>grade 1 as per the classification proposed by Schultz and colleagues)[18]. The success rate of approximately  $\geq 90\%$  cannulation of the desired duct is a parameter to measure competency in performing ERCP [19].

The perforation rate following ERCP in our study was lower (0.14%) than in the three previous, where the rates were 0.45%, 0.72%, and 0.39%, respectively [4, 5, 17]. Participating physicians in CORI-NED database are provided with an electronic health record completed at the endoscopy time and generate procedure reports. Once submitted, the report cannot be altered. Hence only the perforations detected during the peri-operative period are reported in the database. Thus only early perforations following ERCP are reported and studied. This may explain the low perforation rate reported in our study. However, research on perforations from the CORI-NED has revealed that extended, more complicated procedures carried out in high-volume centres by high-volume endoscopists are a factor in perforations. This is likely due to



high-risk procedures with complex pathology been undertaken at tertiary and quaternary centers.

Early diagnosis is most important to reduce associated significant morbidity and mortality rates; thus, prompt management should be initiated as soon as possible. The late recognition of ERCP-related perforation, failure to adequately treat a perforation, and delayed surgery following failed non-operative management worsen outcomes [4, 19-22].

The strength of the study is that <sup>1</sup>the CORI-NED was utilized <sup>2</sup>as the primary data source. CORI has <sup>3</sup>strict quality-control measures for all its data. The data repository is checked for anomalies on a daily basis, and unusual activity prompts contact by CORI staff [9]. Moreover, the data is derived from a variety of gastroenterology practice settings, with the majority of sites covered being community-based, followed by veterans' administration and academic hospitals. This provides an evaluation of real-world representation of the practice of endoscopy.

#### *Limits of the study*

Our study results should be considered in light of its <sup>2</sup>limitations, most of which are inherent to large database studies. First, this study is prone to site-selection bias. The sites unwilling to share data with CORI-NED may differ in their clinical practice from the participating sites. Generally, smaller practices with higher administrative burdens do not participate in additional data sharing on databases. These practices also refer complex procedures to high-volume centers and endoscopists. It is also likely that less experienced practitioners rarely publish their data [16, 23]. Second, CORI-NED database does not give the specific type of perforation encountered during the ERCP procedure. Thus we could not differentiate into duodenal perforation, peri-ampullary or bile duct perforation. Third, the endoscopic report was the source of data in this study. The CORI-NED database only records the clinical information and events during and immediately after the ERCP in the endoscopic report. Additionally, follow-up data analysis in CORI is limited. Hence delayed perforations would not have been picked up

in the study. However, a review of 18 retrospective studies showed that most (73%) perforations are identified during the periprocedural period [17].

## Conclusion

Our study shows that the increase in procedure complexity raises the requisite expertise to deal with complex pathology successfully. ERCP will continue its exponential growth to deal with more complex hepatobiliary pathologies. In order to raise the expertise of future endoscopists, higher volume centers with adequate training procedure numbers for aspiring endoscopists are the need of the hour.

## **ARTICLE HIGHLIGHTS**

### ***Research background***

ERCP is a widely performed procedure in Gastroenterology. ERCP perforations are rare complication however they lead to severe morbidity and can be fatal.

### ***Research motivation***

CORI-NED is a large prospectively accrued population-based database maintained by NIH. NIH established CORI <sup>1</sup> in 1995 to study the use and outcomes of endoscopy in diverse gastroenterology practice settings in the United States. Our motivation was to study this large database and look into the complications associated with ERCP.

### ***Research objectives***

ERCP were stratified based on the endoscopist and center volume (quartiles), complexity of the ERCP and total procedure duration based on procedure details. The effects of these variables on the perforations were studied.

### ***Research methods***

ERCP related data from CORI NED database from 2000-2012 was analyzed. Continuous variables were compared between perforation (Perf) and no perforation (NoPerf)

groups using Mann-Whitney U test as the data demonstrated significant skewness and Kurtosis.

### ***Research results***

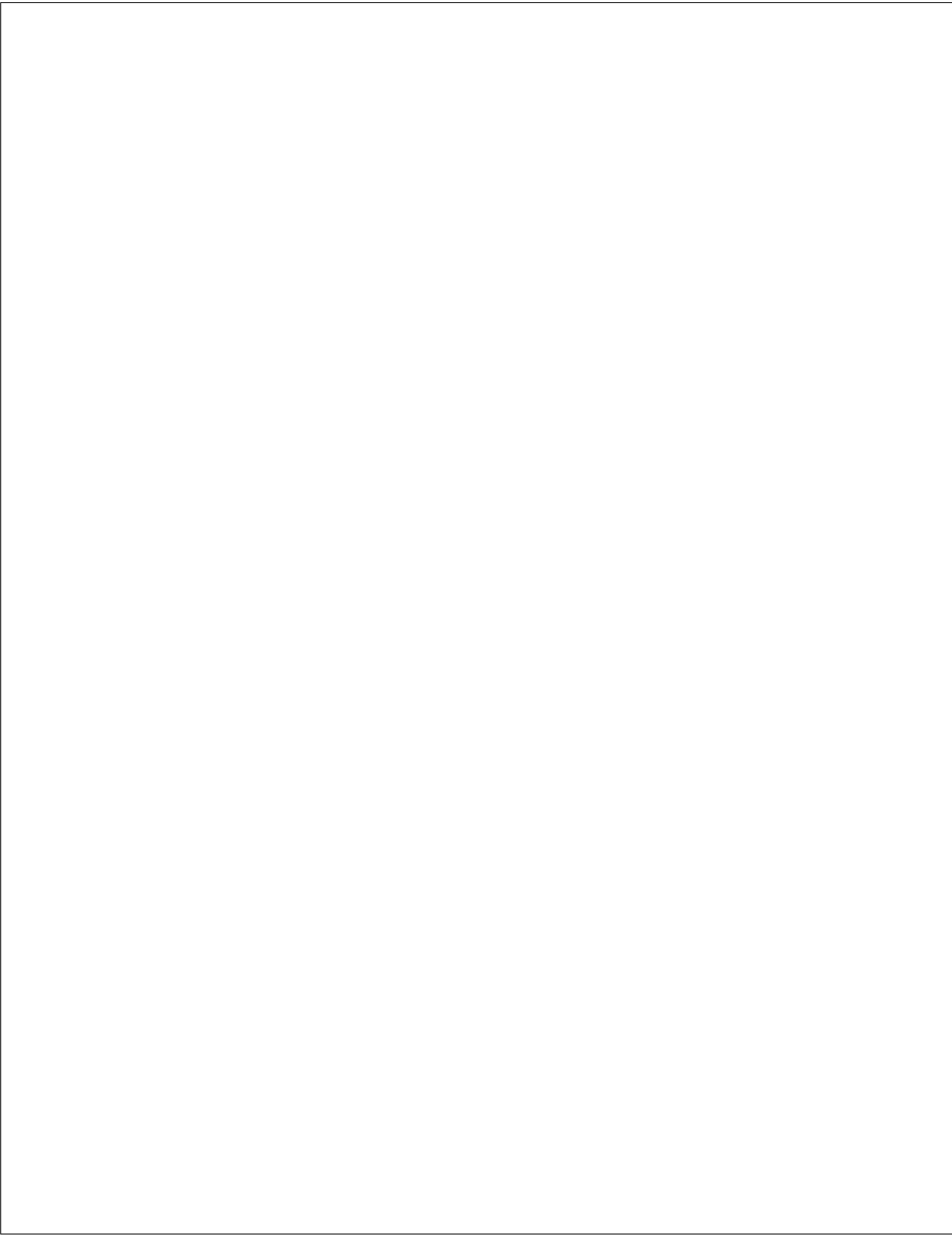
14,153 ERCPs performed by 258 endoscopists at 48 facilities were analyzed. 20 perforations (0.14%) were reported among 16 endoscopists. The cannulation rate for perforations vs no perforations was 100% and 91.5%, respectively. 11/20 (55%) of perforations happened in the centres with the greatest volumes (4th quartile), while 13/20 (65%) of endoscopists were high-volume achievers. Total procedure duration in minutes was  $60.1 \pm 29.9$  vs.  $40.33 \pm 23.5$  (Perf vs. NoPerf,  $p < 0.001$ ). Half of the procedures were complex and more than grade 1 difficulty (Table 1). 3 out of 20 (15%) patients had prior biliary surgery. 13 out of 20 cases (65%) had sphincterotomies with stent insertion. 1 case (0.5%) had peritonitis.

### ***Research conclusions***

Overall adverse events as a composite during ERCP are known to occur at a lower rate with higher volume endoscopists and centers.

### ***Research perspectives***

We analyzed the profile of perforations related to ERCP from the CORI-NED database over 12 years. The retrospective analysis of 14,153 ERCPs performed by 258 endoscopists reported 20 perforations (0.14%) among 16 endoscopists. The cannulation rate was 100% for perforation and 91.5% for no perforation groups. 65% of endoscopists were high-volume performers, and 55% of perforations occurred in centers with the highest volumes (4th quartile). Higher volume endoscopists and centres are known to have less ERCP-related adverse events. However, this national database study on perforations has shown prolonged and complex procedures performed by high-volume endoscopists at high-volume centers contributed to perforations.



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