

Endoscopic perforation rates at a Canadian university teaching hospital

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T Misra, E Lalor, RN Fedorak. Endoscopic perforation rates at a Canadian university teaching hospital. *Can J Gastroenterol* 2004;18(4):221-226.

BACKGROUND: Despite advances in training, operative techniques and endoscopic technology, upper and lower endoscopic procedures continue to have potential for intestinal perforation. Perforation rates provided to patients at the time of consent have frequently been derived from historical cohorts and survey datasets. **OBJECTIVE:** This study examined the perforation rates of upper and lower endoscopic procedures at a major Canadian tertiary care centre.

METHODS: Inpatient and outpatient gastroscopies and colonoscopies performed during a three year period were evaluated. Endoscopies with perforations occurring within 14 days of procedure were retrospectively isolated using the *International Classification of Diseases – 9th Revision* code descriptions, then retrieved and hand searched to confirm a procedure-related perforation. Data were extracted to identify risk factors and patient outcomes.

RESULTS: A total of 21,217 endoscopies (13,792 gastroscopies and 7425 colonoscopies) were reviewed. Of these, 359 were identified, isolated and hand searched for confirmation of a perforation event. Eighteen were found to have an endoscopy-associated perforation. Ten perforations occurred with colonoscopy (0.13%) (incidence, 1.3/1000 procedures), resulting in one death (0.013%) (incidence, 0.13/1000 procedures). Eight perforations occurred with gastroscopy (0.06%) (incidence, 0.6/1000 procedures), resulting in zero mortality. Of colonoscopy procedures the rate of perforation with diagnostic colonoscopy was 0.13% (incidence, 1.3/1000 procedures) and with therapeutic colonoscopy was 0.14% (incidence, 1.4/1000 procedures). Of gastroscopy procedures the rate with therapeutic gastroscopy was 0.15% (incidence, 1.5/1000 procedures). No perforations occurred with diagnostic gastroscopy.

CONCLUSION: Gastroscopy and colonoscopy procedures, especially those with therapeutic maneuvers, continue to carry morbidity and mortality risks associated with perforation.

Key Words: Colonoscopy; Complication; Endoscopy; Gastroscopy; Morbidity; Mortality; Perforation

Upper and lower flexible endoscopy has evolved into an important diagnostic and therapeutic tool that has revolutionized the management of patients with gastrointestinal diseases. Although flexible upper and lower endoscopy, with current endoscopic equipment and appropriate training is considered a safe procedure, like all other procedures in medicine, there remains identifiable potential for adverse events and complications. One of the most serious of these complications is intestinal perforation.

Taux de perforation liés aux endoscopies dans un centre hospitalier universitaire au Canada

CONTEXTE : Malgré les progrès réalisés dans la formation, les techniques d'utilisation et la technologie, les endoscopies digestives hautes et basses comportent toujours des risques de perforation de l'intestin. Les taux de perforation présentés aux patients au moment du consentement proviennent souvent de cohortes historiques et de données d'enquêtes.

OBJECTIF : La présente étude a porté sur les taux de perforation liés aux endoscopies hautes et basses, effectuées dans un grand centre de soins tertiaires au Canada.

MÉTHODE : Nous avons évalué les gastroscopies et les coloscopies pratiquées sur des patients externes et des patients hospitalisés sur une période de trois ans. Les endoscopies suivies d'une perforation notée dans les 14 jours après l'intervention ont été repérées de façon rétrospective à l'aide des codes de la Classification internationale des maladies, 9^e édition, puis récupérées et soumises à une recherche manuelle pour confirmer le lien entre la perforation et l'intervention. L'extraction des données avait pour but de relever les facteurs de risque et les résultats de l'examen.

RÉSULTATS : Au total, 21 217 endoscopies (13 792 gastroscopies et 7425 coloscopies) ont été passées en revue. Sur ce nombre, 359 ont fait l'objet d'une recherche manuelle en vue d'une confirmation de la perforation, et 18 dossiers se sont avérés des cas de perforation liés à l'endoscopie. Dix perforations ont été associées à la coloscopie (0,13 %) (incidence : 1,3/1000 interventions), dont une s'est soldée par la mort du patient (0,013 %) (incidence : 0,13/1000 interventions). De son côté, la gastroscopie a été associée à huit perforations (0,06 %) (incidence : 0,6/1000 interventions), et aucune n'a entraîné la mort du patient. En ce qui concerne les coloscopies, le taux de perforation associé aux interventions diagnostiques était de 0,13 % (incidence : 1,3/1000 interventions) et celui associé aux interventions thérapeutiques, de 0,14 % (incidence : 1,4/1000 interventions). Quant aux gastroscopies, le taux de perforation associé aux interventions thérapeutiques était de 0,15 % (incidence : 1,5/1000 interventions). Pour ce qui est des gastroscopies à visée diagnostique, elles n'ont donné lieu à aucune perforation.

CONCLUSION : Les gastroscopies et les coloscopies, notamment à visée thérapeutique, comportent toujours des risques de morbidité et de mortalité associés aux perforations.

Table 1 outlines the published reports of colonoscopy-associated perforation rates during the last 30 years. The reported rate of colonic perforation ranges from a high of 1.3% to a low of 0% (1-18). Studies with the highest reported rate of perforations are those conducted at a time when colonoscopy was a relatively new procedure, and may not be representative of current colonoscopic practice. In contrast, retrospective and prospective studies conducted since 1996 have reported lower rates of perforation, with diagnostic colonoscopic perforation

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Received for publication June 25, 2003. Accepted February 12, 2004.

TABLE 1
Published reports of colonoscopy-associated perforation rates during the last 30 years

Author year (ref)	Number of procedures	Perforation rate (%)	Mortality rate (%)	Comments
Diagnostic colonoscopy				
1975, Rogers et al (1)	25,298	0.22	0.008	ASGE survey
1976, Smith (2)	12,746	0.26	0.016	Survey
1979, Fruhmorgen and Demling (3)	28,527	0.14	0.020	Multicentre survey article
1979, Stuart et al (4)	442	1.30	0.200	Retrospective single centre
1983, Macrae et al (5)	3205	0.12	0	Retrospective single centre
1984, Gilbert et al (6)	4713	0.17	NA	ASGE survey
1990, Fruhmorgen and Pfahler (7)	6609	0.05	0.015	Retrospective single centre
1992, Reed et al (8)	1000	0.12	0	General surgeon survey
1992, Waye et al (9)	1320	0	0	Ambulatory office procedures, prospective single endoscopist
1996, Puchner et al (10)	8989	0.08	0	Retrospective single centre
1999, Eckardt et al (11)	2500	0.04	0	
2000, Anderson et al (12)	6291	0.19	0	Retrospective single centre
2001, Sieg et al (13)	82,416	0.005	0.001	Prospective multicentre outpatients only
2001, Dafnis et al (15)	4677	0.11	0	Retrospective multicentre
2001, Wexner et al (16)	13,580	0.07	NA	Prospective general surgeons
Total	202,313	0.09	0.006	
Therapeutic colonoscopy				
1975, Rogers et al (1)	6214	0.29	0	ASGE survey
1976, Smith (2)	9238	0.52	0.01	Polypectomy-associated
1979, Stuart et al (4)	184	0	0	Polypectomy-associated
1979, Fruhmorgen and Demling (3)	7365	0.34	0.10	Polypectomy-associated
1983, Macrae et al (5)	1795	0.11	0	Polypectomy-associated
1984, Gilbert et al (6)	1901	0.11	NA	Polypectomy-associated
1988, Nivatvongs (17)	1576	0.06	0	Polypectomy-associated
1990, Fruhmorgen and Pfahler (7)	2306	0.20	0	Polypectomy-associated
1992, Waye et al (9)	777	0.30	0	Polypectomy-associated
1996, Puchner et al (10)	1609	0.20	0.20	Polypectomy-associated
1996, Kewenter and Brevinge (18)	513	0.80	0	Polypectomy-associated
2000, Anderson et al (12)	4195	0.19	0.05	Polypectomy-associated
2001, Sieg et al (13)	14,249	0.06	0.007	Polypectomy-associated
2001, Dafnis et al (15)	1389	0.22	0	Two-thirds polypectomy-associated
Total	53,311	0.24	0.03	

ASGE American Society for Gastrointestinal Endoscopy; NA Not available

rates ranging from 0.005% to 0.20% (10-16) and therapeutic colonoscopic perforation rates ranging from 0.06 to 0.40% (11-15). Indeed, a recent diagnostic colonoscopic screening program for colon cancer in a healthy population involving over 3000 colonoscopies had a zero rate of perforation (19), implying the risk of colonoscopy-associated perforation may be lowest during screening of a healthy outpatient population.

Table 2 outlines the published reports of gastroscopy-associated perforation rates during the last 30 years. The rate of perforation with diagnostic gastroscopy has been described as lower than that of perforation associated with diagnostic colonoscopy. The rate of perforation at the time of diagnostic gastroscopy ranges from 0.0009% to 0.10% (7,13,20-25).

Again, similar to that seen with colonoscopy, the most recent studies report the lowest rates of perforation. Therapeutic gastroscopy carries an increased risk of perforation (range 0.3% to 6.4%) and is almost always associated with dilation of malignant or benign esophageal strictures (21,25). Interestingly, upper endoscopic perforations associated with bleeding ulcers was not described until recently, when a therapeutic endoscopic upper gastrointestinal bleeding clinical trial documented a perforation rate of 1.1% and 4.2% for endoscopic treatment and re-treatment, respectively (26).

Perforation rates provided to patients at the time of consent are frequently derived from the historical cohorts and survey data sets identified in Tables 1 and 2. There are currently no published Canadian endoscopic perforation data. The aim of

TABLE 2
Published reports of gastroscopy-associated perforation rates during the last 30 years

Author year (ref)	Number of procedures	Perforation rate (%)	Mortality rate (%)	Comments
Diagnostic gastroscopy				
1972, Schiller et al (22)	23,500	0.11	0.004	Survey
1974, Mandelstam et al (23)	211,410	0.03	0.002	ASGE survey
1987, Miller (24) NA	0.008	NA		
1990, Fruhmorgen and Pfahler (7)	NA	0.01	NA	
1995, Quine et al (25)	13,036	0.05	0.008	Retrospective multicentre
2001, Sieg et al (13)	110,469	0.0009	0.0009	Prospective multicentre, outpatient
Total	358,415	0.03	0.002	
Therapeutic gastroscopy				
1992, Muhldorfer et al (21)	NA	0.5	0.05	Dilation – bougienage
1992, Muhldorfer et al (21)	NA	0.3	0.50	Dilation – balloon
1992, Muhldorfer et al (21)	NA	5.0	4.00	Esophageal stents
1992, Muhldorfer et al (21)	NA	1.0	2.00	Sclerotherapy
1992, Muhldorfer et al (21)	NA	1.0	NA	Hemostasis nonvariceal bleed
1992, Muhldorfer et al (21)	NA	5.0	2.00	Laser treatment
1995, Quine et al (25)	554	1.1	0.50	Retrospective multicentre: dilation of benign stricture
1995, Quine et al (25)	220	6.4	2.30	Dilation of neoplastic stricture
Total		2.6	1.0	

ASGE American Society for Gastrointestinal Endoscopy; NA Not available

this retrospective chart review was to determine recent Canadian gastroscopy- and colonoscopy-associated perforation rates at a Canadian tertiary care university teaching centre.

METHODS

The University of Alberta Hospital is a university teaching centre and a tertiary care referral hospital located in Edmonton, Alberta. It serves a catchment area of over 1.8 million people from central/northern Alberta, northwestern Saskatchewan, northern British Columbia and the Northwest Territories. Endoscopy at the University of Alberta Hospital is performed by three pediatric gastroenterologists, four hepatologists, six adult gastroenterologists and one general surgeon. Approximately 4500 gastroscopies and 2500 colonoscopies are performed annually. The hospital also serves as a Canadian training centre for between five to 10 gastroenterology subspecialty residents in any given year.

All inpatient and outpatient upper and lower endoscopies conducted at the University Hospital between January 1, 1998 and December 31, 2001 were evaluated. The University of Alberta Hospital uses the *International Classification of Diseases (ICD) (27)*, on a prospective basis, to identify each procedure and diagnosis for every patient encounter. Previous reports have shown that over 90% of perforations resulting from endoscopy are diagnosed within two days of the procedure (12). Endoscopies with perforations, occurring within 14 days of the endoscopic procedure, were therefore isolated using the code descriptions listed in Table 3.

Identified records were retrieved and hand searched to confirm an endoscopic-associated perforation by consensus of two authors (TM and RF). Data were extracted to identify patient demographics, endoscopic indication and diagnosis, type of procedure, extent of insertion, preparation adequacy, trainee involvement, previous abdominal surgery, renal failure, surgical outcome and mortality. The type of procedure was recorded as either diagnostic or

TABLE 3
ICD code descriptions for endoscopies with perforations

Endoscopic procedures	Diagnosis
Anoscopy	Accidental cut/hemolysis during surgery
Closed biopsy of large intestine	Accidental cut/hemolysis with scope
Closed biopsy of rectum	Accidental puncture/laceration during procedure
Colonoscopy	
Dilation of anal sphincter	Hemorrhage of the gastrointestinal tract
Dilation of esophagus	Other specific disorders rectum/anus
Dilation of intestine	Perforation of intestine
Dilation of pylorus	Peritonitis
Dilation of rectum	Pneumomediastinum
Esophagogastroduodenoscopy	Pneumonitis
Esophagoscopy	Pneumoperitoneum
Flexible sigmoidoscopy	Pneumothorax
Gastroscopy	
Other endoscopy small intestine	
Percutaneous gastrostomy	
Polypectomy	
Rigid protosigmoidoscopy	

ICD *International Classification of Diseases*

therapeutic depending on the presence or absence of a therapeutic endoscopic maneuver. For gastroscopy, therapeutic maneuvers included dilation, stent placement, variceal and nonvariceal hemostatic procedures, and percutaneous endoscopic gastrostomy tube placement. For colonoscopy, therapeutic maneuvers included all therapeutic procedures identified for gastroscopy, plus polypectomy and decompression. The occurrence of mucosal biopsy was recorded as a diagnostic procedure.

TABLE 4
Frequency of endoscopic perforations at the University of Alberta Hospital August 1998 to August 2001

	Gastroscopy			Colonoscopy		
	Diagnostic	Therapeutic	Total	Diagnostic	Therapeutic	Total
Number of procedures	8062	5330	13,392	4470	2955	7425
Number of perforations	0	8	8	6	4	10
Perforation rate	0%	0.15%	0.06%	0.13%	0.14%	0.13%

TABLE 5
Characteristics of patients with perforation following colonoscopy

Patient	Sex	Age (years)	Procedure type	Diagnosis	Trainee associated with the procedure	Previous abdominal surgery	Renal failure	Adequate preparation documented
1	F	74	Diagnostic	Diverticuli	No	No	No	Not stated
2	M	64	Diagnostic	Diverticuli	Yes	No	No	Yes
3	M	44	Decompression	Ischemia, megacolon	No	No	No	Poor
4	F	45	Stricture dilation	Colonic stricture	No	No	No	Yes
5	M	58	BICAP bleeding ulcer	Colonic ulcer	No	No	No	Poor
6	F	70	Diagnostic	Normal	No	Appendectomy	No	Yes
7	F	75	Diagnostic	Diverticuli	Yes	Cholecystectomy, hysterectomy	Hemodialysis	Not stated
8	F	61	Diagnostic	Severe colitis	Yes	No	Hemodialysis	Poor
9	M	70	Diagnostic	Normal	Yes	No	No	Not stated
10	F	42	Polypectomy	Benign neoplasm	No	No	No	Not stated

BICAP Bipolar electrocoagulation; F Female; M Male

RESULTS

As shown in Table 4, a total of 21,217 endoscopies (13,792 gastroscopies [diagnostic 8062, therapeutic 5330] and 7425 colonoscopies [diagnostic 4470, therapeutic 2955]) were performed in the 36 months between August 1998 and August, 2001. Three hundred fifty-nine (167 inpatients and 192 outpatients) records were initially isolated for review based on the search criteria outlined above. Of these 359 cases, 358 were retrieved. One record of a colonoscopy was not reviewed because it was missing from the files. After hand searching all 358 retrieved cases, 18 of these records were found to have had an endoscopy-associated intestinal perforation.

Colonoscopy

Ten colonic perforations occurred during the 7425 colonoscopies, representing an overall colonoscopic perforation rate of 0.13% (incidence, 1.3/1000; 1/769 procedures) (Table 3). Six colonoscopy-associated perforations occurred during 4470 diagnostic colonoscopies (0.13%) (incidence, 1.3/1000; 1/769 procedures), while four colonoscopy-associated perforations occurred during 2955 therapeutic colonoscopies (0.14%) (incidence, 1.4/1000; 1/714 procedures).

Table 5 demonstrates the characteristics of patients with colonoscopic perforation. The mean age was 60.3±6.2 years with male:female ratio of 4:6. One patient died following the perforation (0.013%) (incidence, 0.13/1000; 1/7692 procedures). Of the 10 colonic perforations, four of 10 (40%) were undergoing a therapeutic colonoscopic procedure (dilation of benign stricture, one patient, hemostasis, one patient, decompression, one patient, polypectomy, one patient). Of the six perforations in patients undergoing diagnostic colonoscopy, five of six (85%) occurred in association with the following

comorbid conditions: two occurred in the setting of diverticulosis, one patient was on hemodialysis, one patient had previous abdominal surgery, and one patient had a combination of diverticulosis, hemodialysis and history of abdominal surgery. Three of 10 (30%) perforations (two therapeutic and one diagnostic colonoscopy) occurred because the colonoscopy was performed in a poorly prepped colon, although the state of the preparation was not reported in four of the perforations, perhaps underestimating the importance of adequate preparation in risk of perforation. Trainees were performing the colonoscopy at the time of perforation in four of 10 (40%) of the cases (four diagnostic colonoscopies).

Management of patients following the identification of perforation varied considerably (Table 6). The diagnosis of perforation was made during the procedure in six of 10 (60%) of the cases and on x-ray, immediately following the procedure, in three of 10 (30%) of the cases and at autopsy in one case (10%). One patient was managed conservatively, two required primary surgical closure, four required surgical resection with anastomosis, two underwent surgical resection with ostomy formation and one died. The one death occurred in a critically ill patient in the intensive care unit, following a recent lung transplant. A colonoscopy was performed up to 30 cm and terminated due to very severe colitis. The patient then became bradycardic and arrested. The autopsy report confirmed an old walled off perforation in the area of the sigmoid, which likely worsened with insufflation of air during the procedure.

Gastroscopy

Eight upper gastrointestinal perforations occurred during the 13,392 gastroscopies, representing a perforation rate of 0.06% (incidence, 0.6/1000; 1.0/1667 procedures) (Table 4). No

gastroscopy-associated perforations occurred during 8062 diagnostic gastroscopies (0%), while eight gastroscopy-associated perforations occurred during 5330 therapeutic gastroscopies (0.15%) (incidence, 1.5/1000; 1/667 procedures).

Table 7 demonstrates the characteristics of the patients with a perforation during gastroscopy. The mean age of the patients involved was 62.4±8.2 years with a male:female ratio of 5:3. Of the eight gastroscopic perforations, all eight (100%) involved a therapeutic procedure (esophageal dilations for malignant lesions, six patients, esophageal wall-stent placement, one patient, placement of percutaneous feeding tube, one patient). Three patients had a positive history of abdominal surgery. No patients had dialysis-dependent renal failure. Two of eight (25%) perforations occurred in the setting of trainee involvement. There were no deaths reported following any gastroscopic perforations.

Like colonoscopy, the management of perforation following gastroscopy varied considerably (Table 8). The diagnosis of perforation was made during the procedure in three of the cases, and on x-ray, immediately following the procedure, in five of the cases (chest x-ray, three patients, gastrograffin swallow, two patients). Five patients were managed conservatively, one had an esophageal stent placed in the operating room to seal the perforation, and two underwent thoracotomies for esophageal repair. The surgically managed patients were discharged from hospital within 11 days of admission.

DISCUSSION

A review of previous publications suggests that the gastrointestinal perforation rate for diagnostic and therapeutic gastroscopy has remained relatively constant over the last several decades (Table 2), whereas the perforation rate for both diagnostic and therapeutic colonoscopy appears to have fallen, and then plateaued, during the last decade (Table 1). The reason for this change in colonoscopic complication rate likely relates to the more recent introduction of colonoscopy into the mainstream of gastrointestinal procedures and the advances that have since occurred in endoscopic equipment, techniques and operator training. Nevertheless, in these same reported cohorts (Tables 1 and 2) it is interesting to note that the average rate of perforation is approximately 85-fold higher for therapeutic gastroscopy (approximately 2.6%) than for diagnostic gastroscopy (approximately 0.03%); and threefold higher for therapeutic colonoscopy (approximately 0.24%) than for diagnostic colonoscopy (approximately 0.09%); while mortality is

TABLE 6
Outcomes of patients with perforation following colonoscopy

Patient	Diagnosis of perforation	Intervention	Death
1	During procedure	Resection—primary anastomosis	No
2	Free air on x-ray	Conservative management	No
3	Free air on x-ray	Resection—ostomy	No
4	During procedure	Resection—ostomy	No
5	During procedure	Resection—primary anastomosis	No
6	During procedure	Primary closure of perforation	No
7	During procedure	Resection—ostomy	No
8	At autopsy	No	Yes
9	During procedure	Resection—primary anastomosis	No
10	Free air on x-ray	Primary closure of perforation	No

approximately 500-fold higher for therapeutic gastroscopy (approximately 1.0%) than for diagnostic gastroscopy (approximately 0.002%); and 50-fold higher for therapeutic colonoscopy (approximately 0.03%) than for diagnostic colonoscopy (approximately 0.006%).

While over-reporting of perforations was avoided by the use of hand searching, it is possible that the lower rates of perforation observed in the current study may reflect under-reporting by the use of ICD codes to retrieve cases in a retrospective manner. However, the data obtained in this study are nonetheless superior to previous documentation using survey techniques.

Perforation at gastroscopy almost always occurred with dilation of a benign or a malignant esophageal stricture. In contrast, perforation at colonoscopy occurred with polypectomy, diverticulosis, poor preparation, previous abdominal surgery (and presumably adhesions) and dialysis-dependent renal failure. Except for dialysis, these associations with perforation have been previously described. Because the prevalence of these associated diagnoses is likely to be relatively high, it is not possible to associate these with risk factors for perforation.

The involvement of trainees as a significant factor in endoscopic perforation has not been previously confirmed (12). The current study had trainees involved in a minority of the cases; however, it was similarly impossible to determine the risk associated with trainees in that the total number of endoscopic cases the trainees were involved in was not

TABLE 7
Characteristics of patients with perforation following gastroscopy

Patient	Sex	Age (years)	Procedure	Diagnosis	Trainee associated with the procedure	Previous abdominal surgery	Renal failure
1	M	70	Esophageal dilation	Esophageal carcinoma	Yes	No	No
2	M	57	Feeding tube placement	Feeding concerns	No	No	No
3	M	79	Esophageal wall stent placement	Esophageal carcinoma	No	Gastric-esophageal resection	No
4	F	17	Esophageal dilation	Esophageal benign stenosis	Yes	Jejunal interposition	No
5	F	76	Esophageal dilation	Gastric cardia carcinoma	No	Gastric carcinoma resection, esophageal-jejunal anastomosis	No
6	F	86	Esophageal dilation	Esophageal carcinoma	No	Unknown	No
7	M	47	Esophageal dilation	Achalasia	No	No	No
8	M	67	Esophageal dilation	Esophageal carcinoma	No	No	No

F Female; M Male

TABLE 8
Outcomes of patients with perforation following gastroscopy

Patient	Diagnosis of perforation	Intervention	Death
1	Gastrograffin	Conservative	No
2	Pneumomediastinum on chest radiograph	Conservative, repeat gastroscopy normal three days later	No
3	Pneumomediastinum on chest radiograph	Conservative	No
4	Pneumothorax on chest radiograph	Thoracotomy – primary esophageal repair and right upper lobe wedge resection	No
5	During procedure	Conservative, repeat dilation 10 days later	No
6	During procedure	Conservative	No
7	During procedure	Thoracotomy – primary esophageal repair	No
8	Gastrograffin	Esophageal stent placed in operating room to seal perforation	No

determined. Nevertheless, operator training and experience has been clearly shown to correlate with endoscopic adverse events, including perforation (28).

Reporting of endoscopic complication rates in patient consent forms is moving from the use of historical cohort data to site specific data, and more recently, it has been suggested that individual operator rates be recorded and reported (28). In this regard, the perforation rates described in the present report reflect those at the University of Alberta Hospital and may not be relevant to individual operators, or to sites where the risk mix is different than that at the University of Alberta Hospital.

CONCLUSION

In summary, endoscopic gastroscopy and colonoscopy procedures, especially those with therapeutic maneuvers, carry risks associated with perforation morbidity and mortality. Future prospective studies are required to clearly determine the associated comorbid risk factors for endoscopic perforation.

ACKNOWLEDGEMENT: Crohn's and Colitis Foundation of Canada

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