Less barium enema, more colonoscopy: A 12-year nationwide population-based study in Taiwan

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Abstract

Background: Colorectal cancer (CRC) is the second most common and third most fatal cancer in Taiwan. To reduce incidence and mortality rates from cancer, including CRC, the Health Promotion Administration in Taiwan initiated the National Program on Cancer Prevention in 2005. For patients who have a positive fecal occult blood test, colonoscopy is recommended, and double-contrast barium enema (BE) is reserved as an alternative for those who cannot receive colonoscopy. In addition, single-contrast BE is sometimes used in pediatrics to evaluate colonic condition. This study evaluated the usage trends of BE and colonoscopy in Taiwan.

Methods: Data from the National Health Insurance Research Database from 2001 to 2013 were used in this study. Patients who received BE and colonoscopy were identified using the procedure codes of the National Health Insurance program. Age-standardized, yearly rates of BE and colonoscopy procedures were calculated.

Results: According to the data, the total number of colonoscopies increased 3.7-fold from 2001 to 2013. The compound annual growth rates for BE and colonoscopy were –5.36% and 10.47%, respectively, during the same period. The compound annual growth rates for BE and colonoscopy were –3.89% and 11.64% from 2005 to 2009, and –11.36% and 9.82% from 2010 to 2013, respectively. BE was conducted significantly more frequently than colonoscopy in patients who were aged <12 years and in female patients.

Conclusion: Professional association guidelines, national cancer prevention programs, patient and physician preferences, and increasing awareness and knowledge of CRC may all contribute to the increasing use of colonoscopy and the dramatic decline in the use of BE in Taiwan.

Keywords: Barium enema; Colonoscopy; Colorectal cancer; Taiwan

1. INTRODUCTION

Colorectal cancer (CRC) is the second most commonly diagnosed cancer in Taiwan.[1] In 2014, a total of 15 764 cases were diagnosed with an age-standardized incidence rate of 44.7 per 100 000 people and an age-standardized mortality rate of 15.3 per 100 000 people, making CRC the third most fatal type of cancer in Taiwan.[1] To reduce incidence and mortality rates of cancer including CRC, the Health Promotion Administration of Taiwan (formerly the Bureau of Health Promotion) instigated the Five-Year National Program on Cancer Prevention and Treatment Control (2005-2009), and the 2nd National Cancer Control Program (2010-2013).[2] In these programs, patients with positive fecal occult blood test (FOBT) were recommended to receive colonoscopy, with double-contrast barium enema (BE) reserved as an alternative for those who were unable to receive colonoscopy.[2]

Double-contrast BE was once a common screening tool for CRC; however, since 2008, the US Preventive Services Task Force recommendations have no longer included double-contrast BE as a CRC screening option.[3] A shift to using abdominal imaging tools has been reported.[4,5] A dramatic 91.9% decline in the utilization of double-contrast BE occurred between 1994 and 2012 in the United States.[6] The changes may be related to a screening consensus established by many organizations and national cancer prevention programs. In addition, single-contrast BE is sometimes used for evaluating colonic condition in pediatric populations.

Data on the utilization of colonoscopy and BE are scarce in Asia. Using records retrieved from Taiwan's National Health Insurance (NHI) system's database, our study investigated the use of BE and colonoscopy, which groups of patients received BE most often, and which types of medical specialists ordered BE most frequently. We hypothesized that there would be a shift from conducting BE to conducting colonoscopy in Taiwan.

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Conflicts of interest: The authors declare that they have no conflicts of interest related to the subject matter or materials discussed in this article.

Journal of Chinese Medical Association. (2019) 82: 312-317.

Received January 26, 2018; accepted February 19, 2018.

doi: 10.1097/JCMA.0000000000000074.

2. METHODS

2.1. Database

This study used a cross-sectional analysis of CRC screening over time. The NHI program is the primary provider of health insurance in Taiwan. The program was launched in 1996, and >99.6% of the population in Taiwan was enrolled by 2016.[7] The NHI research database (NHIRD), which contains NHI claims data, is updated by the National Health Research Institutes each year. The NHIRD contains patients' sex, dates of birth, clinical visits, hospitalizations, drugs prescribed, dosages, and diagnosis codes. Diagnosis codes are encoded using the International Classification of Disease, Ninth Revision, Clinical Modification (ICD-9-CM). Personal identification information is encrypted before releasing the research database to protect patient privacy. In this study, a cohort dataset of 1 million people was randomly sampled to represent all NHI beneficiaries (Longitudinal Health Insurance Database [LHID], 2005). Both hospitalization and ambulatory records, including encrypted personal identification numbers, dates of birth, sex, procedure codes (as defined in the fee schedule and reference lists for medical services of the NHI), and specialties of the physician in charge were analyzed. Additionally, the registry for contracted medical facilities (HOSB) was used to identify the category of each hospital. This study was conducted in accordance with the Declaration of Helsinki and was approved by the Institutional Review Board of Taipei Veterans General Hospital according to the law of the Republic of China, Taiwan (VGHIRB No.: 2013-04-005E).

2.2. Identification of BE and colonoscopy cases

NHI claims data from 2001 to 2013 were used in this study. Patients who received BE and colonoscopy were identified through the NHI procedure codes 33011B and 28017C, respectively, on their medical records. Utilization rates were calculated per 1000 beneficiaries. The hospitals performing BE and colonoscopy were identified as medical centers, regional hospitals, or local hospitals.

2.3. Data analysis

Data management and collection were conducted using PostgreSQL version 9.34 (PostgreSQL Global Development Group). Statistical analyses were performed using IBM SPSS Statistics for Windows, version 21.0 (IBM Corp., Armonk, NY, USA). The compound annual growth rate (CAGR) was calculated using the following equation to represent the overall usage trend:

$$CAGR = \left((N2013 \div N2001)^{1/12}\right) - 1$$

The CAGR during the Five-Year National Program on Cancer Prevention and Treatment Control (2005-2009) was calculated using the following equation to represent the usage trend:

$$CAGR = \left((N2009 \div N2005)^{1/4}\right) - 1$$

The CAGR during the 2nd National Cancer Control Program (2010-2013) was calculated using the following equation to represent the usage trend:

$$CAGR = \left((N2013 \div N2010)^{1/3}\right) - 1$$

Categorical variables were compared using chi-squared or Fisher's exact test, as appropriate, and continuous variables were compared using Student's *t* test. Distribution differences in the use of the two procedures were compared based on age, sex, inpatient vs outpatient, hospital category, and specialty of physicians using chi-squared test.

3. RESULTS

3.1. Overall usage

A total of 147 547 records dating from 2001 to 2013 were retrieved and analyzed (Table 1 and Fig. 1). Based on the sampling data, the total number of BE conducted decreased from 1930 in 2001 to 943 in 2013. By contrast, the total number of colonoscopies increased from 3873 in 2001 to 14 139 in 2013, representing a 3.7-fold increase. The CAGR for BE and colonoscopy were –5.36% and 10.47% during the same period, respectively (Table 2). Of all the 21 066 cases who received BE, 2190 (10.4%) received colonoscopy or sigmoidoscopy in the subsequent 3 months. Conversely, only 2% of patients (2576 out of 126 481) who underwent colonoscopy or sigmoidoscopy received BE in the subsequent 3 months.

3.2. Usage differences based on duration of the National Cancer Prevention and Cancer Control Program

The total number of colonoscopies increased from 6262 in 2005 to 9728 in 2009 and from 10 675 in 2010 to 14 139 in 2013. The total number of BE decreased from 1904 in 2005 to 1624 in 2009 and from 1354 in 2010 to 943 in 2013. The CAGRs for BE and colonoscopy were –3.89% and 11.64%, respectively, during the Five-Year National Program on Cancer Prevention and Treatment Control (2005-2009). The CAGRs for BE and colonoscopy were –11.36% and 9.82%, respectively, during the 2nd National Cancer Control Program (2010-2013). Significant CAGR differences were found between BE and colonoscopy ($p < 0.001$). Significant CAGR differences were also found between the overall use (2001-2013) and use during the 2nd National Cancer Control Program (2010-2013) ($p < 0.05$).

3.3. Usage differences based on age, sex, inpatient vs outpatient, and hospital category

BE was conducted significantly more frequently than colonoscopy in patients who were aged <12 years (Table 3). The overall use of BE and colonoscopy was most frequent in patients aged 41 to 65 years. BE was conducted significantly more frequently in female patients, whereas colonoscopy was conducted significantly more frequently in male patients. Most BE and colonoscopy were performed in outpatient settings. BE was conducted significantly less frequently in inpatient settings than in outpatient settings ($p < 0.001$). In addition, BE was conducted significantly less frequently in medical centers than colonoscopy was.

3.4. Usage differences based on specialty of physicians

With regard to the specialties of the physicians who ordered the most BEs and colonoscopies, the top two specialties were internal medicine and surgery (Table 4). More than 94% of BE and

Table 1

Total numbers of double-contrast barium enema and colonoscopy procedures conducted in Taiwan retrieved from 2001 to 2013 as determined by via a cohort dataset of one million randomly sampled people randomly sample (Longitudinal Health Insurance Database [LHID], 2005)

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Barium enema	1930	2035	1690	1914	1904	1834	1967	1656	1624	1354	1097	1118	943
Colonoscopy	3873	4308	4315	5837	6262	6867	7716	8099	9728	10675	10776	12250	14139

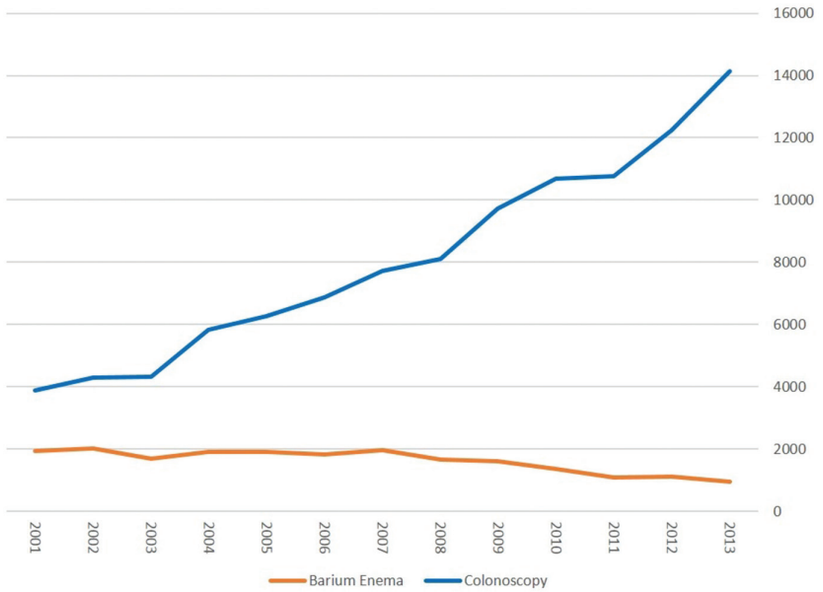

Fig. 1 Total number of barium enema, sigmoidoscopy, and colonoscopy procedures recorded from 2001 to 2013 pertaining to a cohort of 1 million people randomly sampled from Taiwan's National Health Insurance database.

colonoscopy examinations were ordered by internists and surgeons. From 2001 to 2013, the number of colonoscopies ordered by internists increased from 2278 in 2001 to 9103 in 2013 and the number of colonoscopies ordered by surgeons increased from 1372 in 2001 to 4523 in 2013 (Figs. 2A, B). The number of BEs ordered by internists decreased from 1172 in 2001 to 407 in 2013 and the number of BEs ordered by surgeons decreased from 620 in 2001 to 514 in 2013. Notably, radiologists ordered BE more frequently than colonoscopy.

4. DISCUSSION

Double-contrast BE can facilitate full examination of the entire structure of the colon in almost all cases[8] and was once widely applied for CRC screening.[9] However, double-contrast BE is a labor-intensive procedure that is limited by the operator's dependence on a radiologist or technologist to perform the examination, as well as by the radiologist's interpretation of the examination.[4,8] Furthermore, the effectiveness of polyp or even cancer detection using double-contrast BE is less than that of colonoscopy. In experienced hands, the sensitivity and specificity of colonoscopy in detecting advanced adenomas and cancer have been reported to range from 70% to 93% and from 86% to 97%, respectively.[8] By contrast, because of the heterogeneity of studies examining BE, the reported sensitivity of double-contrast BE to detect advanced adenomas and cancer has ranged widely from 48% to 97%.[8] Moreover, double-contrast BE procedures provide no opportunity to conduct a biopsy or polypectomy.[8] Therefore, since 2008, double-contrast BE has no longer been a preferred CRC screening method recommended in the guidelines of the American College of Gastroenterology nor was it advocated by the US Preventive Services Task Force in 2016.[10,11]

Ferrucci et al.[9] reviewed double-contrast BE studies performed in a single institution, finding that even from 2001 to 2004, when double-contrast BE was still considered an alternative for CRC screening, the most common indication (44.6%) for a double-contrast BE was a failed or inconclusive colonoscopy.[9] In the last 12 years, most guidelines and screening programs have recommended the use of colonoscopy or computed tomography (CT) colonography rather than double-contrast BE for CRC screening. Moreover, it is also relatively easy for patients to access colonoscopy; therefore, it is perhaps inevitable that colonoscopy and CT colonography will ultimately replace double-contrast BE for CRC screening.[4,6,10-13]

Many studies have revealed that colonoscopies are technically more difficult to perform in women than in men, especially in women who have undergone abdominal or gynecological surgery such as hysterectomy or cesarean section.[14–16] Women who have previously undergone a hysterectomy reportedly experience more pain during colonoscopy.[17] Consequently, women may be less likely to undergo colonoscopy.[18,19] Women are more likely to undergo FOBT screening, whereas men are more likely to undergo endoscopic screening examinations.[18,19] Acceptance and knowledge of CRC screening among men is higher than among women in both Taiwan and Hong Kong.[20,21] This explains one of our study results: the fact that male patients underwent more colonoscopies than female patients (Table 3).

Major hurdles for pediatric colonoscopy include the high level of technical ability required, poor compliance with bowel clearance, and uncooperativeness during the procedure.[22] A total of 62% of pediatric colonoscopies were reported to be performed under general anesthesia, and 38% were performed under intravenous sedation.[23] Of the 8841 colonoscopies included in a previous study, complications were recorded in 1.1%, and of these, 56.8% were reported as gastrointestinal complications, 35.2% as cardiopulmonary complications, and 10.2% as miscellaneous complications including drug reaction or rash.[23] For evaluating rectal bleeding, polypoid lesions in the colon, and colitis in children, the diagnostic sensitivity and specificity of BE and flexible colonoscopy do not differ significantly.[24] In children aged 4 to 18

Table 2

The compound annual growth rate (CAGR) of procedures retrieved from 2001 to 2013, during Five-Year National Program on Cancer Prevention and Treatment Control (2005-2009) and during the 2nd National Cancer Control Program—Cancer Screening (2010-2013)

	CAGR 2001-2013, %	CAGR 2005-2009, %	CAGR 2010-2013, %	*p*
Barium enema	–5.36	–3.89	–11.36	<0.05
Colonoscopy	10.47	11.64	9.82	<0.05

Table 3

Total number of procedures analyses according to age distribution, gender, inpatients and outpatients distribution, and patient distribution according to hospital category

	Barium enema	Colonoscopy	*p*
Age, years			<0.001
<12	128	95	
12–18	221	453	
19–40	3423	16 513	
41–65	10 022	57 737	
>65	7272	31 174	
Gender			<0.001
Female	11 269	49 354	
Male	9797	56 618	
Inpatient/outpatient			<0.001
Inpatient	1980	13 089	
Outpatient	19 086	92 883	
Hospital category			<0.001
Local hospital	3536	21 010	
Regional hospital	9257	38 109	
Medical center	8273	46 853	

years, the "3–7 pump" method of BE has been successful in both inpatient and outpatient settings.[25] Determination of potential colonoscopy-related complications and their expected frequencies in children can result in enhanced risk–benefit analysis by physicians and patients.[23] The slightly higher risk of severe complications in children compared with in adults might also restrict the use of colonoscopy in pediatric patients.[26] This may explain our observation that BE was conducted more frequently than colonoscopy in patients under the age of 12 years (Table 3).

In 2004, to reduce cancer mortality rates and expand the provision of cancer screening services, the Health Promotion Administration in Taiwan initiated the Five-Year National Program on Cancer Prevention and Treatment Control (2005-2009).[2] Our analysis revealed a rapid acceleration in the number of colonoscopies performed in 2004 (Fig. 1). The CAGR of colonoscopy during 2005-2009 was 11.64%, which was clearly linked to the nationwide cancer screening program.

The Health Promotion Administration also instigated the 2nd National Cancer Control Program (2010-2013).[2] The screening for CRC included two phases. Phase 1 used FOBTs for screening; patients with positive FOBT results were referred for phase 2 screening involving confirmatory diagnosis through colonoscopy. The screening rate among people aged 50 to 69 years in 2012 and 2013 was 38.2%. In 2013, polyps were diagnosed in 26 207 people, and 2030 people were diagnosed with CRC.[2] Our analysis revealed a second sharp acceleration in the number of colonoscopies performed in 2011 (Fig. 1). The CAGR of colonoscopy during 2005-2009 was 9.82%, which was also clearly related to the aforementioned national cancer screening program.

CRC screening guidelines and national cancer prevention programs are not the only factors that influence which procedure is chosen for CRC screening or screening for other colorectal conditions. In an assessment of patients' preferences for CRC screening procedures, colonoscopy was significantly preferred over double-contrast BE.[27] Physicians' attitudes also play a crucial role. Gastroenterologists and surgeons preferred to recommend colonoscopy rather than double-contrast BE as a screening test for CRC in a questionnaire sent to gastroenterologists, internists, and surgeons in Alberta, Canada.[28] A survey conducted in 2000 concluded that radiologists view double-contrast BE for CRC screening far more positively than primary care physicians,[5] and this might explain the observation in our study that radiologists ordered double-contrast BE more frequently than colonoscopy. In addition, sedated colonoscopy has become more popular in the United States.[29] In Taiwan, sedated colonoscopy has also become more easily accessible; however, although colonoscopy can be reimbursed through the NHI program, fees for "sedation" during colonoscopy are not reimbursable and therefore not available in the data provided from the NHIRD. Nonetheless, based on clinical observation, increased use of sedated colonoscopy seems to be a crucial reason for the growth in colonoscopy conducted in Taiwan.

This study had several limitations. First, the diagnostic report of each BE or colonoscopy could not be identified from the dataset. Thus, the diagnostic accuracy of BE or colonoscopy could not be analyzed. Second, the completeness of each BE or colonoscopy could not be identified from the dataset. Therefore, the precise usage rate of BE and colonoscopy could be overestimated by analyzing the administrative dataset. However, in usual clinical settings, most BEs and colonoscopies are conducted successfully; thus, the completeness of each BE or colonoscopy should not have a confounding effect on our analysis.

In conclusion, professional association guidelines, national cancer prevention program involvement, patients and physician preferences, and increasing awareness and knowledge of CRC may all contribute to the increasing use of colonoscopy and corresponding dramatic decline in the use of BE.

Table 4

Total number of procedures analyses according to specialty of physicians

	Barium enema	Colonoscopy	*p*
Specialty			<0.001
Internal medicine	10 990	65 990	
Surgery	9096	35 251	
Emergency medicine	7	556	
Gynecology	110	270	
Radiology	211	158	
Pediatric	144	174	

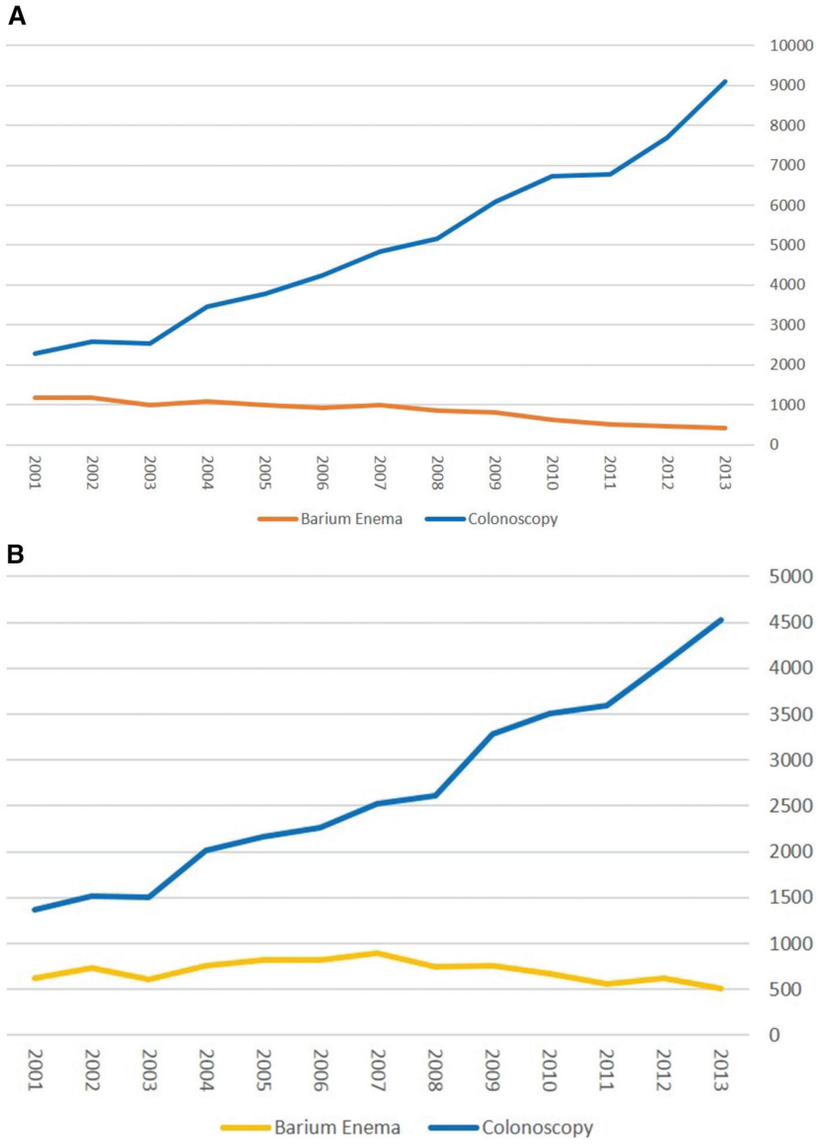

Fig. 2 A, Total number of barium enema, sigmoidoscopy, and colonoscopy procedures ordered by internists from 2001 to 2013. B, Total number of barium enema, sigmoidoscopy, and colonoscopy procedures ordered by surgeons from 2001 to 2013.

ACKNOWLEDGMENTS

This study was supported by grants from Taipei Veterans General Hospital (VGH-106-D10-002-MY2-2, V107C-025, V107D31-001-MY3-1) and the Ministry of Science and Technology (MOST106-2410-H-010-018) in Taiwan. This study was based in part on data from the NHIRD provided by the NHI Administration, Ministry of Health and Welfare, and managed by the National Health Research Institutes. The interpretation and conclusions contained herein do not represent those of the NHI Administration, Ministry of Health and Welfare, or the National Health Research Institutes.

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