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Gastrointestinal and Nongastrointestinal Complications of Esophagogastroduodenoscopy and Colonoscopy in the Real World: A Nationwide Standard Cohort Using the Common Data Model Database

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Background/Aims: The global trend of an expanding aged population has increased concerns about complications correlated with gastrointestinal (GI) endoscopy in elderly patients; however, there have been few reports published on this issue.

Methods: In this retrospective, observational cohort study performed between 2012 and 2017, serious complications of esophagogastroduodenoscopy (EGD), colonoscopy, and colonoscopic polypectomy were compared between patients according to age (≥ 65 years vs 18–64 years). We used the Health Insurance Review and Assessment-National Patient Samples database, previously converted to the standardized Observational Medical Outcomes Partnership-Common Data Model. Serious complications within 30 days of the procedure included both GI complications (bleeding and perforation) and non-GI complications (cerebrovascular accident [CVA], acute myocardial infarction [AMI], congestive heart failure [CHF], and death).

Results: A total of 387,647 patients who underwent EGD, 241,094 who underwent colonoscopy, and 89,059 who underwent colonoscopic polypectomy were assessed as part of this investigation. During the study period, endoscopic procedures in the older group steadily increased in number in all endoscopy groups (all $p < 0.001$). Further, pooled complication rates of bleeding, CVA, AMI, CHF, and death were approximately three times higher among older patients who underwent EGD or colonoscopy. Moreover, pooled complication rates of CVA, AMI, CHF, and death were approximately 2.2 to 5.0 times higher among older patients who underwent colonoscopic polypectomy.

Conclusions: Elderly patients experienced approximately three times more GI and non-GI complications after EGD or colonoscopy than young patients. Physicians should pay attention to the potential risks of GI endoscopy in elderly patients. (*Gut Liver* 2021;15:569-578)

Key Words: Esophagogastroduodenoscopy; Colonoscopy; Complications; Population; Common Data Model

INTRODUCTION

Esophagogastroduodenoscopy (EGD) and colonoscopy are commonly performed gastrointestinal (GI) procedures that carry a low risk of complications. Most previous studies have focused on assessing GI complications of EGD and colonoscopy,^{1,2} while only a few have analyzed non-GI complications.³⁻⁶ As complications of EGD and colonoscopy

are very rare, a large number of cases may be necessary to capture the exact rates of GI and non-GI complications associated with these procedures. Therefore, only population-based research may yield the exact magnitude of complications associated with EGD and colonoscopy. Yet, few population-based studies have reported on the complications of EGD and colonoscopy.^{4,7} In a prospective audit of upper GI endoscopy, the mortality and morbidity rates of

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diagnostic EGD were 1/2,000 and 1/200, respectively.⁸ In a single-center study, only two complications were reported from 12,841 diagnostic EGDs.⁹ After outpatient EGD, 2.5% of patients required an emergency department or physician visit, and 1.1% required hospitalization within 30 days.¹⁰ The Clinical Outcomes Research Initiative database showed a cardiopulmonary event rate of 1/170 and a mortality rate of 1/10,000 after 140,000 upper GI procedures.³ In a systemic review of 57,742 screening colonoscopies, the pooled rate of overall complications was 2.8/1,000 procedures.⁷ In the United States, the complication rate from mostly diagnostic colonoscopies was 5/1,000 procedures.¹¹ A recent systematic review reported a perforation rate of 4/10,000 and major bleeding rate of 8/10,000 associated with screening colonoscopy.¹ The variable rates of complications associated with EGD and colonoscopy in previous studies³⁻⁵ may be explained by differences in data source, patient population, healthcare resources, follow-up duration, and definitions of complications. Further, most previous studies were conducted in Western countries,^{1,5-7,12} and the complication rates of EGD and colonoscopy in Asian countries may be different from those of Western countries. Gathering exact knowledge on the expected complications of EGD and colonoscopy in the real world may help to minimize development of those complications.

Recently, the use of EGD and colonoscopy in elderly patients has been increasing as the diagnostic role of GI endoscopy is growing among this population. This trend likely increases the potential complications of GI endoscopy, but we currently have little information regarding their safety in elderly patients. In a recent population-based study, old age was an independent risk factor for cardio-cerebrovascular complications after EGD and colonoscopy.⁴ Knowledge of potential complications of GI endoscopy in elderly patients may facilitate to careful selection of patients for appropriate indications and enable the operator to be familiar with the planned procedure and prepared to manage any complications that may arise in elderly patients. Therefore, a population-based study including elderly patients is necessary to assess the exact magnitudes of GI and non-GI complications associated with EGD and colonoscopy in the real world.

In this context, we sought to assess the GI and non-GI complications of EGD and colonoscopy in the real world using a nationwide standard cohort paired with the Common Data Model (CDM) database.

MATERIALS AND METHODS

1. Data source

We used the Health Insurance Review and Assessment-National Patient Samples (HIRA-NPS) database from 2012 to 2017, previously converted to the standardized Observational Medical Outcomes Partnership-CDM. The HIRA is a repository of claims data collected during the process of reimbursing healthcare providers for services funded and covers all citizens in South Korea under the universal coverage system.¹³ The database contains comprehensive and rich information pertaining to healthcare services, such as treatments, pharmaceuticals, procedures, and diagnoses, for almost 50 million beneficiaries in South Korea.¹³ However, HIRA data have limitations in terms of accessibility and convenience to secure timely data, because the database's annual size is about one billion people or more. Therefore, sample data (i.e., HIRA-NPS) of HIRA were compiled to overcome these limitations. HIRA-NPS is a 3% representation of the national patient sample (encompassing about 1,000,000 people) per year extracted using a stratified randomized sampling method according to sex and age group at the patient level. It includes about 13% (approximately 700,000) of inpatient and 1% (approximately 400,000) of outpatient data, including all medical claims and prescriptions data for 1 year, which are calculated under the assumption of acceptable sampling error range and normal distribution for the optimal size of HIRA-NPS.

However, it is difficult to characterize or analyze the data from HIRA-NPS and each hospital's data (especially international hospital data) in the same way or using the same tools because healthcare datasets are stored in databases that are built using a wide variety of data models and, often, local terminologies.^{14,15} An analysis across multiple disparate databases must either be tailored to accommodate each of the underlying data models and terminologies or convert the databases to a CDM.¹⁴ Recently, HIRA-NPS was converted to the Observational Medical Outcomes Partnership-CDM, in which disparate coding systems can be harmonized to a standardized vocabulary with minimal information loss.^{14,15} Variable terms for HIRA-NPS, which are typically expressed in nonstandard terms, were redeveloped into standard concepts using mapping. As HIRA data were initially recorded using the International Classification of Diseases, ninth revision codes, they were mapped to Systematized Nomenclature for Medicine-Clinical Terms codes in CDM data.¹⁴ As the Observational Medical Outcomes Partnership-CDM version of the HIRA-NPS database is provided as an open source in South Korea, it has advantages over the original HIRA-NPS database, which

was limited by a preapproval for use, a usage fee, and limited use within a predetermined platform for online or offline use. This study was approved by the Institutional Review Board of Kyung Hee University (IRB number: 2020-04-043), and informed consent was waived.

2. Study design

We conducted a retrospective, observational cohort study to address 30-day GI and non-GI complications in patients 18 years or older undergoing outpatient EGD, colonoscopy, or colonoscopic polypectomy between January 1, 2012 and December 31, 2017. We described the demographic characteristics of the study population with each procedure by index year. The incidence rate of serious complications within 30 days of the endoscopy procedure was calculated as number of cases and proportion per 10,000 people by index year according to the type of endoscopy. Variables used in this study were age, age group

(18 to 64 years vs ≥ 65 years), sex, and index year (2012 to 2017). Elderly patients were defined as those 65 years of age and older according to endoscopic practice guidelines for the elderly.¹⁶

3. Definition of cohorts and complications

The EGD cohort was defined as an outpatient population aged 18 years or older who underwent diagnostic EGD for the first person's history under the medical insurance program and no colonoscopy or colonoscopic polypectomy within ± 30 days. For subjects who underwent multiple EGD procedures, the first was considered for analysis. To exclude other invasive endoscopy procedures such as enteroscopy or endoscopic retrograde cholangiopancreatography, only EGD procedures that were not on the same day or within ± 30 days of these other procedures were included. EGD procedures with therapeutic interventions were also excluded from the EGD cohort. The colonoscopy

Table 1. Demographic Characteristics of the Study Population According to EGD, Colonoscopy, or Colonoscopic Polypectomy by Index Year

Demographic characteristics	2012	2013	2014	2015	2016	2017
Diagnostic EGD						
No. of patients	73,204	68,091	64,618	60,364	61,085	60,285
Age, yr	49.9 \pm 15.6	50.3 \pm 15.8	48.6 \pm 15.7	51.0 \pm 16.1	51.0 \pm 16.3	53.9 \pm 16.2
Male sex	34,027 (46.5)	32,265 (47.4)	30,106 (46.6)	28,692 (47.5)	28,990 (47.5)	28,761 (47.7)
Age group						
Young (18–64 yr)	58,534 (80.0)	53,651 (78.8)	53,079 (82.1)	46,523 (77.1)	46,856 (76.7)	39,607 (65.7)
Age	44.4 \pm 12.2	44.5 \pm 12.3	43.7 \pm 12.6	44.6 \pm 12.5	44.5 \pm 12.6	45.0 \pm 11.5
Male sex	27,365 (46.8)	25,388 (47.3)	24,700 (46.5)	21,990 (47.3)	21,951 (46.8)	20,896 (52.8)
Old (≥ 65 yr)	14,670 (20.0)	14,440 (21.2)	11,539 (17.9)	13,841 (22.9)	14,229 (23.3)	20,678 (34.3)
Age	71.6 \pm 4.9	71.8 \pm 5.1	71.3 \pm 4.7	72.2 \pm 5.3	72.4 \pm 5.3	72.1 \pm 5.8
Male sex	6,670 (45.5)	6,881 (47.7)	5,404 (46.8)	6,708 (48.5)	7,036 (49.4)	12,417 (60.0)
Diagnostic colonoscopy						
No. of patients	40,489	38,398	36,829	38,488	42,840	44,050
Age, yr	52.0 \pm 12.2	52.6 \pm 12.4	50.9 \pm 12.3	53.5 \pm 12.5	54.1 \pm 12.6	57.0 \pm 12.7
Male sex	21,225 (52.4)	19,754 (51.4)	19,074 (51.8)	19,942 (51.8)	22,145 (51.7)	22,870 (51.9)
Age group						
Young (18–64 yr)	34,007 (84.0)	31,546 (82.2)	31,676 (86.0)	30,798 (80.0)	33,598 (78.4)	28,862 (65.5)
Age	48.6 \pm 10.0	44.8 \pm 10.0	47.8 \pm 10.3	49.2 \pm 10.0	49.6 \pm 10.0	50.0 \pm 9.7
Male sex	17,730 (52.1)	16,105 (51.1)	16,406 (51.8)	15,816 (51.4)	17,253 (51.4)	16,374 (56.7)
Old (≥ 65 yr)	6,482 (16.0)	6,852 (17.8)	5,153 (14.0)	7,690 (20.0)	9,242 (21.6)	15,188 (34.5)
Age	70.2 \pm 4.3	70.3 \pm 4.5	69.9 \pm 4.1	70.4 \pm 4.6	70.5 \pm 4.6	70.5 \pm 5.3
Male sex	2,986 (46.1)	3,204 (46.8)	2,486 (48.2)	3,567 (46.4)	4,353 (47.1)	8,251 (54.3)
Colonoscopic polypectomy						
No. of patients	13,133	13,578	13,756	14,944	16,443	17,205
Age, yr	55.7 \pm 10.9	56.0 \pm 11.1	54.2 \pm 11.1	56.6 \pm 11.2	57.1 \pm 11.2	59.9 \pm 11.3
Male sex	8,689 (66.2)	8,922 (65.7)	8,807 (64.0)	9,514 (63.7)	10,475 (63.7)	10,887 (63.3)
Age group						
Young (18–64 yr)	10,136 (77.2)	10,327 (76.1)	11,185 (81.3)	11,101 (74.3)	12,064 (73.4)	9,956 (57.9)
Age	51.5 \pm 8.4	51.5 \pm 8.5	50.6 \pm 8.8	51.8 \pm 8.4	52.2 \pm 8.4	52.1 \pm 7.8
Male sex	6,831 (67.4)	6,864 (66.5)	7,240 (64.7)	7,226 (65.1)	7,791 (64.6)	7,326 (73.6)
Old (≥ 65 yr)	2,997 (22.8)	3,251 (23.9)	2,571 (18.7)	3,843 (25.7)	4,379 (26.6)	7,249 (42.1)
Age	70.1 \pm 4.2	70.2 \pm 4.4	69.8 \pm 4.0	70.4 \pm 4.5	70.7 \pm 4.7	70.6 \pm 5.3
Male sex	1,858 (62.0)	2,058 (63.3)	1,568 (61.0)	2,290 (59.6)	2,684 (61.3)	5,139 (70.9)

Data are presented as mean \pm SD or number (%).

EGD, esophagogastroduodenoscopy.

cohort was defined in the same way as the diagnostic EGD cohort as patients who underwent an outpatient diagnostic colonoscopy for the first person's history under the medical insurance program and who underwent colonoscopy with or without biopsy. Finally, the colonoscopic polypectomy cohort was also defined in the same way and included patients who underwent single or multiple polypectomies and mucosal resections; however, it excluded cases of submucosal dissection or other therapeutic interventions. The strategies for treating colorectal polyp in Korea are similar to those in Western countries,¹⁷ that is, diminutive polyps <5 mm are removed by forceps biopsy and polyps ≥5 mm are removed by snare polypectomy. Concept identification and concept codes of concept sets for endoscopy are described in Supplementary Table 1.

Serious 30-day complications were defined as complications occurring within 30 days of initial procedures and presenting to an emergency department or inpatient visit based on the standard 30-day period in the postsurgical literature and a previous population-based study.¹³ Com-

plications were classified into categories based on Systematized Nomenclature for Medicine-Clinical Terms codes (Supplementary Table 1) as follows: GI (bleeding, perforation) and non-GI (acute myocardial infarction [AMI], congestive heart failure [CHF], cerebrovascular accident [CVA; cerebral hemorrhage or infarction], and death). For death, 30-day in-hospital or emergency department death was analyzed by death domain of CDM.

4. Statistical analysis

Observational Health Data Sciences and Informatics analysis tools are embedded in the interactive analysis platform ATLAS. ATLAS version 2.7.2 was used herein, and we analyzed the platform of FEEDER-NET (Suwon, Korea), a health big-data platform based on Observational Health Data Sciences and Informatics-CDM supported by the Korean National Project.¹⁸ Data were presented as mean±standard deviation for normally distributed continuous variables and as number (percentage) for categorical variables. The chi-square or Fisher exact tests were used to

Table 2. Incidence Rate of Serious Complications within 30 Days of EGD by Age Group between 2012 and 2017

Adverse events	2012 A/B/C	2013 A/B/C	2014 A/B/C	2015 A/B/C	2016 A/B/C	2017 A/B/C
Bleeding						
Subjects, No.	73,145/ 58,499/14,646	68,029/ 53,613/14,416	64,574/ 53,052/11,522	60,302/ 46,487/13,815	61,013/ 46,801/14,212	60,225/ 39,580/20,645
Event cases, No.	55/35/20	60/29/31	62/35/27	40/19/21	39/26/13	51/18/33
Proportion per 10,000 people	7.5/6.5/13.7	8.8/5.4/21.5	9.6/6.6/23.4	6.6/4.1/15.2	6.4/5.6/9.1	8.5/4.5/16.0
Perforation						
Subjects, No.	73,197/ 58,529/14,668	68,078/ 53,640/14,438	64,609/ 53,071/11,538	60,354/ 46,517/13,837	61,075/ 46,847/14,228	60,282/ 39,604/20,678
Event cases, No.	7/3/4	2/2/0	2/1/1	1/0/1	1/0/1	1/1/0
Proportion per 10,000 people	1.0/0.5/2.7	0.3/0.4/0	0.3/0.2/0.9	0.2/0/0.7	0.2/0/0.7	0.2/0.3/0
Cerebral hemorrhage or infarction						
Subjects, No.	73,109/ 58,499/14,610	68,012/ 53,622/14,390	64,528/ 53,038/11,490	60,302/ 46,503/13,799	61,007/ 46,827/14,180	60,229/ 39,594/20,635
Event cases, No.	22/7/15	12/4/8	19/8/11	20/7/13	21/7/14	13/4/9
Proportion per 10,000 people	3.0/1.2/10.3	1.8/0.7/5.6	2.9/1.5/9.6	3.3/1.5/9.4	3.4/1.5/9.9	2.2/1.0/4.4
Acute myocardial infarction						
Subjects, No.	77,945/ 58,394/14,551	67,805/ 53,499/14,306	64,346/ 52,917/11,429	60,072/ 46,364/13,708	60,773/ 46,688/14,085	60,066/ 39,535/20,531
Event cases, No.	22/13/9	30/14/16	34/22/12	32/15/17	32/14/18	19/4/15
Proportion per 10,000 people	3.0/2.2/6.2	4.4/2.6/11.2	5.3/4.2/10.5	5.3/3.2/12.4	5.3/3.0/12.8	3.2/1.0/7.3
Congestive heart failure						
Subjects, No.	73,174/ 58,524/14,650	68,072/ 53,646/14,426	64,600/ 53,072/11,528	60,337/ 46,510/13,827	61,039/ 46,841/14,198	60,251/ 39,602/20,649
Event cases, No.	7/3/4	7/1/6	12/3/9	5/1/4	16/6/10	11/1/10
Proportion per 10,000 people	1.0/0.5/2.7	1.0/0.2/4.2	1.9/0.6/7.8	0.8/0.2/2.9	2.6/1.3/7.0	1.8/0.3/4.8
Death						
Subjects, No.	73,203/ 58,533/14,670	68,091/ 53,651/14,440	64,617/ 53,079/11,538	60,364/ 46,523/13,841	61,085/ 46,856/14,229	60,285/ 39,607/20,678
Event cases, No.	25/12/13	20/7/13	14/8/6	19/5/14	10/2/8	18/2/16
Proportion per 10,000 people	3.4/2.1/8.9	2.9/1.3/9.0	2.2/1.5/5.2	3.1/1.1/10.1	1.6/0.4/5.6	3.0/0.5/7.7

EGD, esophagogastroduodenoscopy; A, all age group; B, young age group (18–64 years); C, old age group (≥65 years).

examine relationships between categorical variables, and t-tests were adopted to compare mean values of continuous variables. All p-values were two-tailed, and those less than 0.05 were considered statistically significant.

RESULTS

1. Demographic characteristics of the study population

A total of 387,647 patients who underwent EGD, 241,094 patients who underwent colonoscopy, and 89,059 patients who underwent colonoscopic polypectomy were captured from the study database between 2012 and 2017 (Table 1). The proportions of sex remained unchanged during the study period. The average age of patients significantly increased in the recent 3 years for EGD, colonoscopy, and colonoscopic polypectomy (all $p < 0.001$). The proportions of elderly patients also significantly increased in recent years for EGD, colonoscopy, and colonoscopic polypectomy (all $p < 0.001$).

2. Serious GI and non-GI complications in EGD

Serious GI and non-GI complications within 30 days after diagnostic EGD were captured and classified by age

group (Table 2). Pooled complication rates of bleeding and perforation were 7.9/10,000 and 0.4/10,000 persons, respectively. Bleeding rates were significantly lower in the younger group than in the older group; however, perforation rates were not significantly lower in the younger group (5.4 vs 16.5, $p < 0.001$ and 0.2 vs 0.8, $p = 0.230$, respectively). For non-GI complications, the pooled complication rates of CVA, AMI, and CHF were 2.8/10,000, 4.4/10,000, and 1.5/10,000 persons, respectively. The CVA, AMI, and CFS rates were significantly lower in the younger group than in the older group (1.2 vs 8.2, 2.7 vs 10.1, and 0.5 vs 4.9, all $p < 0.001$, respectively). The incidence of death within 30 days after EGD was 2.7/10,000 persons and was significantly lower in the younger group than in the older group (1.2 vs 7.8, $p < 0.001$). All these data are summarized in the schematic bar graph in Fig. 1A.

3. Serious GI and non-GI complications in colonoscopy

Serious GI and non-GI complications within 30 days after diagnostic colonoscopy were captured and classified by age group (Table 3). Pooled complication rates of bleeding rate and perforation were 5.1/10,000 and 0.4/10,000 persons, respectively. Bleeding and perforation rates were not statistically different between the younger and older

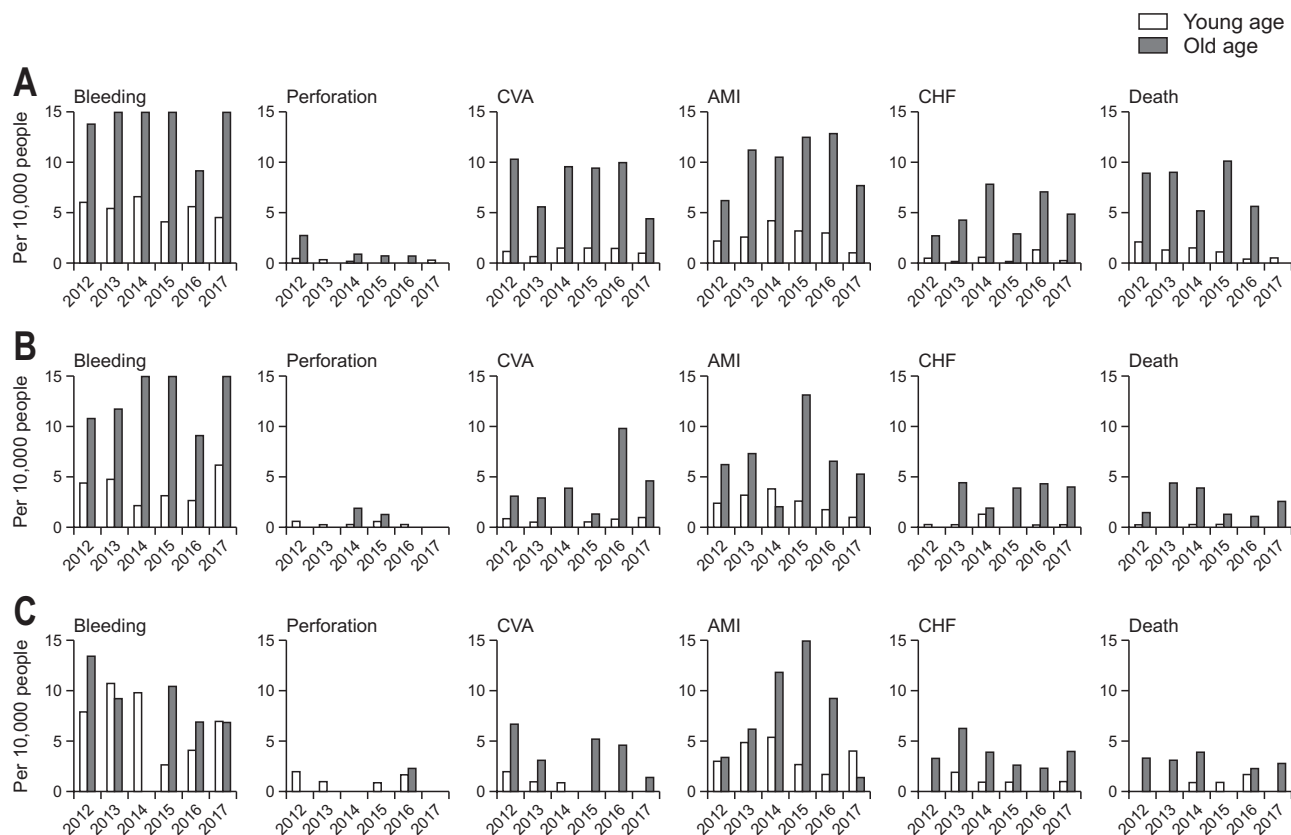


Fig. 1. Serious complication rates (event/10,000 persons) by age groups according to EGD (A), colonoscopy (B), and colonoscopic polypectomy (C). EGD, esophagogastroduodenoscopy; CVA, cerebrovascular accident; AMI, acute myocardial infarction; CHF, congestive heart failure.

Table 3. Incidence Rate of Serious Complications within 30 Days of Diagnostic Colonoscopy between 2012 and 2017

Adverse events	2012 A/B/C	2013 A/B/C	2014 A/B/C	2015 A/B/C	2016 A/B/C	2017 A/B/C
Bleeding						
Subjects, No.	40,460/ 33,990/6,470	38,370/ 31,527/6,843	36,804/ 31,654/5,150	38,463/ 30,780/7,683	42,786/ 33,559/9,227	43,996/ 28,836/15,160
Event cases, No.	22/15/7	23/15/8	16/7/9	13/10/7	19/9/10	31/18/13
Proportion per 10,000 people	5.4/4.4/10.8	6.0/4.8/11.7	4.3/2.2/17.5	3.4/3.2/9.1	4.4/2.7/10.8	7.0/6.2/8.6
Perforation						
Subjects, No.	40,485/ 34,003/6,482	38,388/ 31,537/6,851	36,825/ 31,672/5,153	38,479/ 30,790/7,689	42,825/ 33,586/9,239	44,049/ 28,861/15,188
Event cases, No.	2/2/0	1/1/0	2/1/1	3/2/1	1/1/0	0/0/0
Proportion per 10,000 people	0.5/0.6/0	0.3/0.3/0	0.5/0.3/1.9	0.8/0.6/1.3	0.2/0.3/0	0/0/0
Cerebral hemorrhage or infarction						
Subjects, No.	40,457/ 33,993/6,464	38,367/ 31,528/6,839	36,808/ 31,662/5,146	38,469/ 30,789/7,680	42,801/ 33,574/9,227	44,022/ 28,857/15,165
Event cases, No.	5/3/2	4/2/2	2/0/2	3/2/1	12/3/9	10/3/7
Proportion per 10,000 people	1.2/0.9/3.1	1.0/0.6/2.9	0.5/0/3.9	0.8/0.6/1.3	2.8/0.9/9.8	2.3/1.0/4.6
Acute myocardial infarction						
Subjects, No.	40,365/ 33,932/6,433	38,291/ 31,474/6,817	36,700/ 31,584/5,116	38,326/ 30,701/7,625	42,665/ 33,498/9,167	43,901/ 28,814/15,087
Event cases, No.	12/8/4	15/10/5	13/12/1	18/8/10	12/6/6	11/3/8
Proportion per 10,000 people	3.0/2.4/6.2	3.9/3.2/7.3	3.5/3.8/2.0	4.7/2.6/13.1	2.8/1.8/6.5	2.5/1.0/5.3
Congestive heart failure						
Subjects, No.	40,479/ 34,000/6,479	38,395/ 31,543/6,852	36,823/ 31,673/5,150	38,474/ 30,791/7,683	42,820/ 33,590/9,230	44,033/ 28,857/15,176
Event cases, No.	1/1/0	4/1/3	5/4/1	3/0/3	5/1/4	7/1/6
Proportion per 10,000 people	0.2/0.3/0	1.0/0.3/4.4	1.4/1.3/1.9	0.8/0/3.9	1.2/0.3/4.3	1.6/0.3/4.0
Death						
Subjects, No.	40,489/ 34,007/6,482	38,398/ 31,546/6,852	36,829/ 31,676/5,153	38,488/ 30,798/7,690	42,840/ 33,598/9,242	44,050/ 28,862/15,188
Event cases, No.	2/1/1	3/0/3	3/1/2	2/1/1	1/0/1	4/0/4
Proportion per 10,000 people	0.5/0.3/1.5	0.8/0/4.4	0.8/0.3/3.9	0.5/0.3/1.3	0.2/0/1.1	0.9/0/2.6

A, all age group; B, young age group [18–64 years]; C, old age group [≥65 years].

groups (3.9 vs 9.9, $p=0.059$ and 0.4 vs 0.4, $p>0.999$, respectively). For non-GI complications, the pooled complication rates of CVA, AMI, and CHF were 1.4/10,000, 3.4/10,000, and 1.0/10,000 persons, respectively. The CVA rate was significantly lower in the younger group than in the older group (0.7 vs 4.3, $p=0.038$), while the AMI and CHF rates were not statistically different between the younger and older groups (2.5 vs 6.7, $p=0.116$ and 0.4 vs 3.1, $p=0.079$, respectively). The incidence of death within 30 days after colonoscopy was 0.6/10,000 persons and was lower in the younger group than in the older group without statistical significance (0.2 vs 2.4, $p=0.130$). All these data are summarized in the schematic bar graph in Fig. 1B.

4. Serious GI and non-GI complications in colonoscopic polypectomy

Serious GI and non-GI complications within 30 days after colonoscopic polypectomy were captured and classified by age group (Table 4). Pooled complication rates of bleeding rate and perforation were 7.3/10,000 and 0.8/10,000

persons, respectively. Bleeding and perforation rates were not statistically different between the younger and the older groups (7.0 vs 7.9, $p>0.999$ and 0.9 vs 0.4, $p>0.999$, respectively). For non-GI complications, pooled complication rates of CVA, AMI, CHF were 1.4/10,000, 4.6/10,000, and 1.7/10,000 persons, respectively. However, the CVA, AMI, and CHF rates were not statistically different between the young and the older groups (0.7 vs 3.3, $p=0.648$; 3.6 vs 8.0, $p=0.651$; and 0.8 vs 4.0, $p=0.491$, respectively). The incidence of death within 30 days after colonoscopic polypectomy was 1.1/10,000 persons and was lower in the younger group than in the older group without statistical significance (0.6 vs 2.5, $p=0.937$). All these data are summarized in the schematic bar graph in Fig. 1C.

DISCUSSION

In this large, population-based study, we evaluated the GI and non-GI complications of EGD, colonoscopy, and

Table 4. Incidence Rate of Serious Complications within 30 Days of Colonoscopic Polypectomy between 2012 and 2017

Adverse events	2012 A/B/C	2013 A/B/C	2014 A/B/C	2015 A/B/C	2016 A/B/C	2017 A/B/C
Bleeding						
Subjects, No.	13,122/ 10,126/2,996	13,568/ 10,322/3,246	13,746/ 11,179/2,567	14,931/ 11,092/3,839	16,427/ 12,057/4,370	17,196/ 9,955/7,141
Event cases, No.	12/8/4	14/11/3	11/11/0	7/3/4	8/5/3	12/7/5
Proportion per 10,000 people	9.1/7.9/13.4	10.3/10.7/9.2	8.0/9.8/0	4.7/2.7/10.4	4.9/4.1/6.9	7.0/7.0/6.9
Perforation						
Subjects, No.	13,132/ 10,135/2,997	13,576/ 10,325/3,251	13,755/ 11,184/2,571	14,943/ 11,100/3,843	16,443/ 12,064/4,379	17,205/ 9,956/7,249
Event cases, No.	2/2/0	1/1/0	0/0/0	1/1/0	3/2/1	0/0/0
Proportion per 10,000 people	1.5/2.0/0	0.7/1.0/0	0/0/0	0.7/0.9/0	1.8/1.7/2.3	0/0/0
Cerebral hemorrhage or infarction						
Subjects, No.	13,121/ 10,132/2,989	13,565/ 10,320/3,245	13,752/ 11,182/2,570	14,929/ 11,094/3,835	16,429/ 12,058/4,371	17,196/ 9,955/7,241
Event cases, No.	4/2/2	2/1/1	1/1/0	2/0/2	2/0/2	1/0/1
Proportion per 10,000 people	3.0/2.0/6.7	1.5/1.0/3.1	0.7/0.9/0	1.3/0/5.2	1.2/0/4.6	0.6/0/1.4
Acute myocardial infarction						
Subjects, No.	13,083/ 10,112/2,971	13,531/ 10,294/3,237	13,704/ 11,156/2,548	14,875/ 11,070/3,805	16,373/ 12,022/4,351	17,130/ 9,927/7,203
Event cases, No.	4/3/1	7/5/2	9/6/3	9/3/6	6/2/4	5/4/1
Proportion per 10,000 people	3.1/3.0/3.4	5.2/4.9/6.2	6.6/5.4/11.8	6.1/2.7/15.8	3.7/1.7/9.2	2.9/4.0/1.4
Congestive heart failure						
Subjects, No.	13,131/ 10,136/2,995	13,575/ 10,324/3,251	13,755/ 11,184/2,571	14,939/ 11,097/3,842	16,434/ 12,060/4,374	17,200/ 9,955/7,245
Event cases, No.	1/0/1	4/2/2	2/1/1	2/1/1	1/0/1	5/1/4
Proportion per 10,000 people	0.8/0/3.3	2.9/1.9/6.2	1.5/0.9/3.9	1.3/0.9/2.6	0.6/0/2.3	2.9/1.0/5.5
Death						
Subjects, No.	13,133/ 10,236/2,997	13,578/ 10,327/3,251	13,756/ 11,185/2,571	14,944/ 11,101/3,843	16,443/ 12,064/4,379	17,205/ 9,956/7,249
Event cases, No.	1/0/1	1/0/1	2/1/1	1/1/0	3/2/1	2/0/2
Proportion per 10,000 people	0.8/0/3.3	0.7/0/3.1	1.5/0.9/3.9	0.7/0.9/0	1.8/1.7/2.3	1.2/0/2.8

A, all age group; B, young age group (18–64 years); C, old age group (≥65 years).

colonoscopic polypectomy using a well-defined HIRA-NPS database over a 6-year period. There had been few population-based studies conducted on the exact rates of GI and non-GI complications of these procedures, and previous studies on colonoscopy have been mostly reported from Western countries.^{4,7,12,19-22} The most important finding of the present study was that the rates of serious non-GI and GI complications are higher in the elderly population than in the younger population. The overall complication rates of each endoscopy procedure were similar to those of recent population-based studies despite their heterogeneous time interval (15 days vs 30 days) and targeted population (e.g., screening, diagnostic, therapeutic purpose, or mixed) for endoscopy.^{4,7,12,21-23} Serious GI and non-GI complication rates remain very low in the overall study population; however, the elderly population experienced about three times more complications than those of the younger population when undergoing diagnostic EGD or colonoscopy. As global aging increases and a growing need for GI endoscopy in elderly patients becomes increasingly inevitable

in the real world, the safety of GI endoscopy in elderly patients is an ongoing concern for physicians.²⁴⁻²⁷ Therefore, our study is unique in that the safety of EGD, colonoscopy, and colonoscopic polypectomy is reported with respect to both GI and non-GI complications using a population-based database from Asia.

EGD is generally known to be safe and well-tolerated in the elderly;^{22,25-28} however, its risk is largely related to comorbidity and sedation during the procedure. To our knowledge, there has been no population-based study performed to evaluate GI and non-GI complications after EGD in the elderly population. In our study, the complication rates of GI bleeding, CVA, AMI, CHF, and death were significantly higher in the elderly group. However, the perforation rate remained very low in both age groups, which may be explained by our assessment of only diagnostic EGD. Well-known risk factors of EGD, such as comorbidity, sedative medications, and susceptibility levels for sedatives, have been reported in previous non-population-based research^{22,25} and could have a greater influence on

elderly than younger patients. In the real world, diagnostic EGD is performed in elderly patients with comorbidity and ongoing medication use as necessary, which may increase the complication rate of EGD in the real-world data relative to that in well-controlled prospective clinical trials. Therefore, physicians should pay more attention to the indications of EGD in elderly patients.

Complications of colonoscopy have been more extensively studied than those of EGD. However, there are limited data available for comparing elderly and nonelderly populations. In a systematic review and meta-analysis,²³ elderly patients had a higher risk of complications during and after colonoscopy, like our study. However, direct comparison with our study is difficult due to the heterogeneity of studies included in the meta-analysis, different population and different definition of complications. The recent population-based study reported complication rates of colonoscopy in all age groups,⁷ which showed similar ranges of complication rates with our study. In previous studies, the observed complication rates were generally two to three times higher in the elderly group than young age group, which is consistent with our findings.^{7,23,25,29} A population-based study reported a slightly higher perforation rate in the elderly population from the United States (92 vs 69 per 100,000 persons);³⁰ however, few population-based studies have been performed in Asian countries. The overall perforation rate of colonoscopy has been reported to be lower in Asian countries than in Western countries,^{31,32} which is also consistent with our results. Overall, it is difficult to compare the perforation rate between young and old populations in Asian and Western countries because of the low incidence of perforation; therefore, further comparative population-based investigation is necessary. Elderly patients are more vulnerable to colonoscopy-related complications irrespective of the region and clinical setting.

Colonoscopic polypectomy has been commonly performed and effectively applied for removing adenoma to prevent colorectal cancer,³³⁻³⁶ yet its GI complication rate is at least 4-fold higher than that of colonoscopy alone.^{21,22,30} As the complications of colonoscopic polypectomy have mainly focused on GI events, there have been no population-based studies to capture its non-GI complication rates.^{11,22} In our study, GI complication rates of colonoscopic polypectomy were not significantly different between young and old patients. However, non-GI complication rates of colonoscopic polypectomy were about 3-fold higher in elderly patients than in young patients. These results indicate that non-GI complications are more problematic

than GI complications in elderly patients undergoing colonoscopic polypectomy. Future studies should focus not only on GI complications, but also non-GI complications in elderly patients undergoing colonoscopic polypectomy.

Our study has several limitations. As we used HIRA-NPS, an administrative claims-based database, it is difficult to assess detailed information, such as comorbid diseases or endoscopist and facility characteristics, or detailed clinical data such as indications of EGD or colonoscopy. Furthermore, we could not assess the data of EGD or colonoscopy performed to the patients not under the medical insurance program, which means the possibility of previous endoscopy experience not captured by HIRA-NPS data. But, these cases may be minimal, if any, considering most endoscopies are reimbursed in South Korea. Also, our study included only outpatients, which lead to possible data loss of patients with severe comorbidities. In addition, as inpatient colonoscopy and colonoscopic polypectomy were excluded from this study, patients with more severe comorbidities may be excluded. Our data should be cautiously interpreted as it is not reasonable to directly compare complication rates between colonoscopy group and colonoscopic polypectomy groups because they are different cohorts. The 30-day post-procedure observation period may be arbitrary but is borrowed from the surgical literature and other population-based research from the United States.⁷ Data collection was retrospective, and there are inevitable data quality issues with conversion of HIRA data to the CDM database. However, excellent data quality has been validated in recent studies using CDM databases.^{37,38}

In conclusion, despite GI endoscopy carrying a low risk of complication, elderly patients experienced a roughly 3-fold higher rate of GI and non-GI complications. Physicians should pay attention to non-GI complication risks as well as GI complication risks of GI endoscopy when treating elderly patients.

CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

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AUTHOR CONTRIBUTIONS

Study concept and design: H.I.K., J.M.C. Data acquisition: M.S.K., J.Y.Y. Data analysis and interpretation: H.I.K., J.M.C. Drafting of the manuscript; critical revision of the manuscript for important intellectual content, study supervision: H.I.K., J.M.C. Statistical analysis: H.I.K. Obtained funding: J.M.C. Administrative, technical, or material support: M.S.K., J.Y.Y. Approval of final manuscript: all authors.

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