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Cardiopulmonary events during primary colonoscopy screening in an average risk population

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ABSTRACT

Background: Large colorectal cancer screening studies using primary colonoscopy have reported a low risk of major complications. Studies on diagnostic and therapeutic colonoscopy have pointed to a frequent occurrence of (minor) cardiopulmonary events, and with the steady increase of colonoscopy screening, it is important to investigate their occurrence in colonoscopy screening.

Methods: This study describes the frequency of bradycardia (pulse rate <60 min^{-1}), hypotension (systolic blood pressure (SBP) <90 mmHg), hypoxaemia (blood oxygenation, SaO_2 <90%) and ECG changes during colonoscopy screening in an average-risk population (hospital personnel, n=214, mean age 54.0±3.8, 39.3% male), without significant comorbidity) and aims at identifying subject-related and/or endoscopic factors associated with their occurrence. All data were collected prospectively. During 214 consecutive primary screening colonoscopies under conscious sedation (midazolam and pethidine), on top of pulse rate and SaO_2, blood pressure and a three-channel ECG were recorded every five minutes.

Results: No major complications or relevant ECG changes occurred. Hypoxaemia occurred in 119 (55.6%), hypotension in 19 (8.9%) and bradycardia in 12 subjects (5.6%). In multivariate analysis, the sedation level 3 increased the risk of hypoxaemia (OR 4.8, CI 1.7-13.7), and incomplete colonoscopy (OR 5.3, CI 1.6-18.1) was associated with hypotension. Subjects with bradycardia had a longer mean procedure time (38±12 vs. 29±12 min, p<0.05), which did not turn out as a risk factor in a multivariate analysis.

Conclusions: Mainly procedure-related and not subject-related factors were found to be associated with the occurrence of cardiopulmonary events in primary colonoscopy screening in this relatively healthy screening population.

KEYWORDS

Colonoscopy, monitoring, cardiopulmonary events, complications, sedation

INTRODUCTION

Colorectal cancer (CRC) is posing a major health issue, with each year over 1.2 million cases and an estimated 608,000 deaths worldwide.[1] CRC mortality can be lowered by CRC screening, as early detection of tumours improves disease outcome[2] and the removal of adenomatous polyps is able to reduce CRC mortality.[3] Several CRC screening methods are currently accepted, such as the Faecal Occult Blood Test (FOBT), sigmoidoscopy and colonoscopy, each characterised by advantages and disadvantages.[2] Colonoscopy is currently considered the standard for the detection of colorectal neoplasia and in case of positive findings detected by FOBT or sigmoidoscopy, a colonoscopy has to be performed for verification and possible removal of the lesion.

Colonoscopy as a primary screening method has been implemented in an increasing number of countries, and the US Centre of Disease Control has reported a rising adherence to endoscopy screening in the country.

Colonoscopy is considered a rather safe procedure. Large screening studies have reported a low risk of major complications, such as perforation, bleeding and serious cardiopulmonary complications (e.g. myocardial infarction, arrhythmia).[4,5] However, several studies on clinical diagnostic and therapeutic colonoscopies have reported the occurrence of one or several cardiopulmonary events (e.g. dysrhythmias, ST elevations/depressions, hypoxaemia, bradycardia and hypotension)[2,6] and pointed especially to the high occurrence of hypoxaemia in 64% of the examinations.[7] Such cardiopulmonary events may increase the risk of serious cardiopulmonary complications.[8] In a recent survey of over 12,000 diagnostic and/or therapeutic colonoscopies, the occurrence of cardiopulmonary complications necessitated termination of the examination in 0.25%.[9] With the steady increase of primary and follow-up screening colonoscopies, performed in relatively healthy populations, it is important that data are obtained on the frequency and severity of cardiopulmonary events and to identify factors associated with their occurrence. The primary aim of the present observational study was to assess the frequency of cardiopulmonary events during screening with primary colonoscopy and to identify subject- and procedure-related factors associated with these events.

POPULATION AND METHODS

Study population and colonoscopic procedure

Employees (50 to 65 years) of the Academic Hospital Maastricht, the Netherlands, were invited for colorectal cancer screening by primary colonoscopy. During an appointment prior to the colonoscopy, a standardised short medical history, medication used, and weight were registered by an experienced nurse. Subjects were excluded if they had undergone a colonoscopy within the previous five years, reported severe comorbidity increasing the risk of colonoscopy, were under surveillance for colorectal neoplasia and/or had onset of acute gastrointestinal symptoms in the previous three months.

The study protocol was approved by the Dutch Health Council (Ministry of Health) and the local medical ethics committee. All participants gave written informed consent.

Colonoscopic procedure

A total of 214 unselected, consecutive screening colonoscopies were performed by four experienced endoscopists and information on the endoscopic procedure, including objective colonoscopy quality indicators[10] and reasons for incomplete procedures, were registered using a standardised form.

A polyethylene glycol-based electrolyte solution (Klean Prep, Norgine b.v., Higher Denham, UK) had been given as bowel cleansing, starting 24 hours before colonoscopy. All participants were offered conscious sedation, consisting of midazolam and pethidine. A starting dose was administered intravenously (i.v.) prior to colonoscopy and in case of discomfort during the procedure an additional dose could be given. After caecal intubation, the antispasmodic/anticholinergic agent scopolamine butyl bromide 20 mg was given i.v. in order to relax the colonic wall before instrument retraction for thorough control of the mucosal surface. In case of contraindications medication was not administered. Sedation levels were registered using level 1 for 'awake', level 2 for 'sleepy', level 3 for 'eyes closed, reacts to verbal stimuli' (level 2+3 are targets of conscious sedation), level 4 for 'eyes closed, reacts to physical stimuli' (deep sedation), and level 5 for 'eyes closed, no reaction to verbal or physical stimuli' (general anaesthesia).[11,12]

Cardio respiratory monitoring

Prior to, during and 10 minutes after colonoscopy, pulse rate, blood oxygenation, and a three-channel electrocardiogram (ECG) were monitored continuously in all procedures. Furthermore, systolic (SBP) and diastolic (DBP) blood pressure were measured every five minutes. Hypoxaemia was defined as oxygen saturation (SaO_2) below 90%, lasting several seconds, oxygen being supplemented by nasal catheter if the SaO_2 did not immediately normalise spontaneously. A pulse rate below 60 min^{-1} was defined as bradycardia. Hypotension was defined as an SBP below 90 mmHg. Mean arterial pressure (MAP) was calculated as: MAP= DPB + 1/3 x (SBP-DBP).

Questionnaires

Before colonoscopy, a standardised questionnaire was completed by the participants on medical history (e.g. smoking, hypertension, pulmonary and/or cardiac disease) and after colonoscopy another questionnaire on symptoms during as well as complications and/or symptoms in the first month after the procedure.

Statistical analysis

Dichotomous variables were compared using a χ^2 test, with Fisher's exact test when necessary. Parametric continuous variables were compared using a Student's t-test. Significant variables identified were subsequently included in multivariate logistic regression models, adjusted for age and gender for the following outcome measures: hypoxaemia, bradycardia, and hypotension. All tests were conducted using SPSS version 15.0 (SPSS inc, 2006) and a p-value below 0.05 was considered to be statistically significant (using two-sided tests).

As hypoxaemia was expected to be the most frequent cardiopulmonary event, its frequency of occurrence was defined as the primary outcome measure. Bradycardia and hypertension were secondary outcome measures.

With an α of 0.05 and power of 80%, we were able to detect a minimal difference of 20% in characteristics between groups for hypoxaemia (group sizes 119 and 95), of 25% for hypotension (group sizes 19 and 195), and of 32% for bradycardia (group sizes 12 and 202).

RESULTS

Study population and colonoscopy procedure

The study population had a mean age of 54.0±3.8 years, and consisted of 84 men (39.3%) and 130 women (60.7%). A medical history of hypertension, pulmonary or cardiac disease was present in 41 (19.3%), 11 (5.1%), and 8 (3.8%) subjects, respectively. Furthermore, 36 (16.8%) participants were current smokers. In total, the American Society of Anesthesiologists (ASA) physical status was classified as I/II in 85.5% and III in 14.5% of participants. Medical history was the reason for exclusion in only one subject.

In total, 214 subsequent and unselected screening colonoscopies were monitored. Caecal intubation rate was 92.0%. Adenomas were detected and removed in 51 participants (23.8%). In total 211 (98.6%) participants had chosen to undergo colonoscopy under conscious sedation. No major complications such as bleeding or perforation occurred during or were reported up to one month after colonoscopy.

Cardiopulmonary events

Hypoxaemia, bradycardia, and hypotension, as previously defined, occurred in 119 (55.6%), in 12 (5.6%), and in 19 (8.9%) subjects, respectively, during the colonoscopy procedure. Apart from bradycardia, no relevant ECG changes occurred during or up to ten minutes after colonoscopy. Major cardiopulmonary complications (e.g. symptomatic myocardial ischaemia or dysrhythmias) did not occur during colonoscopy, nor were they reported by participants in the one month follow-up period.

Mean baseline values just before the start of the colonoscopy were 97.4±1.8% for oxygen saturation, 77.3±14.9 min-1 for pulse rate, 147.8±20.8 mmHg for SBP, and 108.2±13.9 mmHg for MAP.

In the group with hypoxaemia, the mean of the lowest SaO_2 value reached was 86.7±2.9% with a mean time of occurrence of 13.2±8.3 min after start of the procedure. Oxygen was supplemented in 82 of these 119 cases (68.6%). In colonoscopies in which hypoxaemia occurred compared with those without hypoxaemia, the mean procedure time was longer (31±12 *vs* 28±12 min, p=0.046), mean dosages of midazolam (0.06±0.02 *vs* 0.05±0.02 mg/kg, p=0.000) and pethidine (0.71±0.18 *vs* 0.58±0.22 mg/kg, p=0.000) were higher, sedation level 3 was more frequent (63.6 *vs* 25.0%, p=0.000), level 1 (10.2 *vs* 32.6%,p=0.00) and level 2 (22.9 *vs* 42.4%, p=0.003) were less frequent, and severe abdominal pain during colonoscopy was more frequent (15.0 *vs* 3.7%, p=0.012) (*table 1*). In a multivariate regression analysis only sedation level 3 (conscious sedation) was associated with hypoxaemia (OR 4.8, CI 1.7 to 13.7).

When using a lower cut-off level for hypoxaemia, as recently proposed by Cotton *et al.*,[13] 19 participants (8.9%) had an SaO_2 below 85%. In this group no statistically significant subject- or procedure-related differences were found compared with the group with an SaO_2 ≥85%.

Table 1. *Differences between participants with or without hypoxaemia (SaO_2<90) during colonoscopy*

	Oxygen saturation		
	Hypoxaemia n=119	Normal n=95	p value*
Participants			
Age	54.4 ±3.9	53.6 ±3.6	0.128
Gender: % women	63.0	57.9	0.483
BMI (kg/m²)	24.7	25.0	0.585
Current smoking %	14.3	20	0.276
History of pulmonary disease %	5.0	5.3	1.000
History of cardiac disease %	2.6	5.3	0.471
History of hypertension %	20.4	18.5	0.730
ASA classification			
- I/II	87.4	84.0	0.560
- III	12.6	16.0	
Procedures			
Procedure time (min)	31 ±12	28 ±12	0.046
Caecal intubation rate %	89.8	94.7	0.214
Sedation medication			
- Midazolam (mg/kg)	0.06 ±0.02	0.05± 0.02	0.000
- Pethidine (mg/kg)	0.71 ±0.18	0.58± 0.22	0.000
Sedation level %			
1. Awake	10.2	32.6	0.000
2. Sleepy (anxiolysis)	22.9	42.4	0.003
3. Eyes closed, reacts to verbal stimuli (conscious sedation)	63.6	25.0	0.000
4. Eyes closed, reacts to physical stimuli (deep sedation)	2.5	0	0.258
5. Eyes closed, unarousable (general anaesthesia)	0.8	0	1.000
Polypectomy and/or biopsies %	52.9	50.5	0.784
Severe abdominal pain during colonoscopy^ %	15.0	3.7	0.012

Variables presented as mean ± SD, or %; ^no significant findings for all other symptoms during colonoscopy; *based on χ^2 or Student's t-test

In the group with bradycardia, the mean lowest value was 43.6 min^{-1} ± 4.0 and the mean time of occurrence was 7.0±3.3 min after procedure start. The mean procedure time was longer compared with those without bradycardia (38±12 *vs* 29±12 min, p=0.014) *(table 2)*. This factor was not significant in the multivariate regression analysis. Two participants had a pre-colonoscopy bradycardia, but had normal pulse rates during colonoscopy.

In the entire study group, blood pressure values were higher before (148±20.8 mmHg for SBP) than at the end of colonoscopy (125±16.4 mmHg for SBP). With respect to hypotension (n=19), the mean nadir SBP was 81.7±7.8 mmHg. The mean procedure time after which hypotension occurred was 19.0±16.6 min. In all participants with hypotensive events, blood pressure normalised spontaneously without i.v. fluid administration. In 13 out of the 19 subjects (68.4%) the pulse rate remained within the normal range, the remainder showed a bradycardia during the hypotensive event. In one case, the hypotensive event was registered as reason for not completing the colonoscopy. The mean decrease in MAP during colonoscopy compared with the baseline MAP was 13±2.3%. A relative decrease of more than 40% occurred in 20 patients (9.3%).
Colonoscopies in which hypotension occurred were less often complete (68.4 *vs* 94.3%, p=0.001), and biopsies and/or polypectomies were less frequently performed (26.3 *vs* 54.4%, p=0.029) **(***table 3***)**. In multivariate regression analysis, only incomplete colonoscopy (OR 5.3, CI 1.6 to 18.1) was associated with hypotension.

Table 2. *Differences between participants with or without bradycardia (pulse rate <60min^{-1}) during colonoscopy*

	Pulse rate		
	Brady-cardia n=12	**Normal n=202**	**p value***
Participants			
Age	54.6 ±4.3	54.0 ±3.7	0.600
Gender: % women	66.7	60.4	0.768
BMI (kg/m^2)	24.9	24.2	0.517
Current smoking %	0	17.8	0.225
History of pulmonary disease %	0	5.4	1.000
History of cardiac disease %	0	4.0	1.000
History of hypertension %	33.3	18.5	0.253
ASA classification			
- I/II	85.6	83.3	0.687
- III	14.4	16.7	
Procedures			
Procedure time (min)	38 ±12	29 ±12	0.014
Caecal intubation rate %	83.3	92.5	0.246
Sedation medication			
- Midazolam (mg/kg)	0.06± 0.03	0.06± 0.02	0.801
- Pethidine (mg/kg)	0.67± 0.22	0.65± 0.21	0.715
Sedation level %			
1. Awake	16.7	20.2	1.000
2. Sleepy (anxiolysis)	16.7	32.3	0.347
3. Eyes closed, reacts to verbal stimuli (conscious sedation)	58.3	46.0	0.553
4. Eyes closed, reacts to physical stimuli (deep sedation)	8.3	1.0	0.163
5. Eyes closed, unarousable (general anaesthesia)	0	0.5	1.000
Polypectomy and/or biopsies %	50.0	52.0	1.000
Severe abdominal pain during colonoscopy^ %	22.2	9.3	0.221

Variables presented as mean ± SD, or %; ^no significant findings for all other symptoms during colonoscopy; *based on χ^2 or Student's t-test

DISCUSSION

With the steady increase of primary and follow-up screening colonoscopies, performed in average risk subjects, data on the frequency and severity of cardiopulmonary events and on factors associated with their occurrence in a screening setting, are of clinical importance. In 214 consecutive screening colonoscopies, no major complications occurred; however, monitoring revealed a frequent occurrence of minor cardiopulmonary events. Mainly procedure-related and not subject-related factors were found to be associated with their occurrence.
Of all cardiopulmonary events, hypoxaemia (<90%) occurred most frequently in more than half of the colonoscopies. It should be noted that the clinical relevance of these hypoxaemic events and the clinical relevance of the cut-off level to be used are still under debate. With a cut-off level of SaO_2 <85%, as recently proposed during an American Society for Gastrointestinal Endoscopy (ASGE) workshop,[13] only 8.9% of the participants would have had such an event. However, it should be taken into account that oxygen administration was immediately started upon an SaO_2 <90 % and this might have prevented a further decrease of the SaO_2 to <85%.
A conscious sedation level, which is usually reached when using moderate doses of midazolam and pethidine, increased the risk for the occurrence of hypoxaemia (defined as SaO_2 <90%).[11] No differences were found in person- and procedure-characteristics between participants with SaO_2 below or above 85%. This may be due to small sample size (i.e. 19 subjects with SaO_2 <85%).
A high frequency of oxygen desaturation occurring in colonoscopies under conscious sedation has been reported by others, although with a substantial

Table 3. *Differences between participants with or without hypotension (SBP <90 mmHg) during colonoscopy*

	Blood pressure		
	Hypo-tension N=19	Normal N=195	p value*
Participants			
Age	55.0 ±4.2	53.9 ±3.7	0.293
Gender: % women	63.2	60.5	1.000
BMI (kg/m²)	24.9	24.2	0.349
Current smoking %	5.3	17.9	0.210
History of pulmonary disease %	0	5.6	0.604
History of cardiac disease %	10.5	3.1	0.154
History of hypertension %	15.8	19.7	1.000
ASA classification			
- I/II	85.1	89.5	1.000
- III	14.9	10.5	
Procedures			
Procedure time (min)	34 ±15	29 ±12	0.120
Caecal intubation rate %	68.4	94.3	0.001
Sedation medication			
- Midazolam (mg/kg)	0.06± 0.02	0.06± 0.02	0.495
- Pethidine (mg/kg)	0.71± 0.13	0.65± 0.22	0.220
Sedation level %			
1. Awake	5.3	21.5	0.132
2. Sleepy (anxiolysis)	42.1	30.4	0.308
3. Eyes closed, reacts to verbal stimuli (conscious sedation)	52.6	46.1	0.635
4. Eyes closed, reacts to physical stimuli (deep sedation)	0	1.6	1.000
5. Eyes closed, unarousable (general anaesthesia)	0	0.5	1.000
Polypectomy and/or biopsies %	26.3	54.4	0.029
Severe abdominal pain during colonoscopy^ %	23.1	8.9	0.125

Variables presented as mean ± SD, or %; ^no significant findings for all other symptoms during colonoscopy; *based on χ^2 or Student's t-test

variation (33 to 64%).[7,14,15] This variation may result from differences in medication (e.g. propofol), differences in population characteristics or use of various cut-off levels. Furthermore, in some studies O_2 was administered preventively or hypoxaemia was defined as such only if it lasted for a certain predefined period of time. Since many studies have reported high frequencies of hypoxaemia, it has been suggested that preventive O_2 administration should be considered, but results from studies are conflicting.[11,16] Some studies have been shown a reduction of the frequency and/or the magnitude of desaturation,[17] whereas others have reported a higher frequency of cardiopulmonary 'unforeseen' events when preventive O_2 was administered.[18]

Bradycardia and hypotension occurred in 6% and 9% of colonoscopies, respectively. This is in line with literature data showing rates of 12% for bradycardia and 6 to 19% for hypotension during diagnostic and therapeutic colonoscopies using various sedatives.[6,14,19-21] It should be noted that for the detection of differences in subject- or procedure-related factors, the sizes of the groups with hypotension and bradycardia were small. Therefore, some potential risk factors, with a weaker association, might have been missed. However, differences in procedure-related factors were found for these group. In the subsequent multivariate analysis no association of subject- and/or procedure-related factors with bradycardia were identified but an incomplete colonoscopy was found to be associated with the occurrence of hypotension. Hypotension was the reason to interrupt the procedure in only one subject. Therefore, occurrence of hypotension is not an explanation for incomplete colonoscopy procedures. A more plausible explanation might be that in incomplete colonoscopies abdominal pain was more frequently present, the dosages of sedatives used were higher, and the sedation level reached was deeper (*data not shown*). Therefore we hypothesise that hypotension may have occurred as a vaso-vagal reaction due to pain and/or as a consequence of higher dosages of sedatives used.

In general, no association was found between pre-existing morbidity and the occurrence of hypoxaemia, hypotension or bradycardia. It has, however, to be considered that this workplace-based population consisted of relatively healthy and health-conscious subjects, in whom the severity of morbidity was probably lower than in many other screening and in most diagnostic and therapeutic colonoscopy populations, in whom a higher ASA classification has been shown to increase the risk for cardiopulmonary events.[22] Furthermore, in the present study, having the advantage of the application of a pre-screening medical interview, one subject was excluded based on severe comorbidity. Exclusion of such subjects with severe comorbidity might further reduce the incidence cardiopulmonary events.

We conclude that, even though the population was relatively healthy, hypoxaemia, arterial hypotension and bradycardia frequently occur during CRC screening with primary colonoscopy under conscious sedation. Procedure-related and not subject-related factors were associated with their occurrence.

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REFERENCES

1. Ferlay J, Shin HR, Bray F, et al. Estimates of worldwide burden of cancer in 2008: GLOBOCAN 2008. International Journal of Cancer. 2010;epub ahead:NA.
2. Levin B, Lieberman DA, McFarland B, et al. Screening and Surveillance for the Early Detection of Colorectal Cancer and Adenomatous Polyps, 2008: A Joint Guideline From the American Cancer Society, the US Multi-Society Task Force on Colorectal Cancer, and the American College of Radiology. Gastroenterology. 2008;134(5):1570-95.
3. Winawer SJ, Zauber AG, Ho MN, et al. Prevention of Colorectal Cancer by Colonoscopic Polypectomy. N Engl J Med. 1993 December 30, 1993;329(27):1977-81.
4. Sieg A, Theilmeier A. [Results of coloscopy screening in 2005--an Internet-based documentation]. Dtsch Med Wochenschr. 2006 Feb 24;131(8):379-83.
5. Wilkins T, LeClair B, Smolkin M, et al. Screening Colonoscopies by Primary Care Physicians: A Meta-Analysis. Ann Fam Med. 2009 January 1, 2009;7(1):56-62.
6. McQuaid KR, Laine L. A systematic review and meta-analysis of randomized, controlled trials of moderate sedation for routine endoscopic procedures. Gastrointestinal Endoscopy. 2008;67(6):910-23.
7. Jaffe P, Fennerty M, Sampliner R, Hixson L. Preventing hypoxemia during colonoscopy. A randomized controlled trial of supplemental oxygen. J Clin Gastroenterol. 1992 Mar;14(2):114-6.
8. Lazzaroni M, Bianchi Porro G. Preparation, Premedication and Surveillance. Endoscopy. 2003;35(02):103-11.
9. Radaelli F, Meucci G, Minoli G. Colonoscopy practice in Italy: A prospective survey on behalf of the Italian Association of Hospital Gastroenterologists. Digestive and Liver Disease. 2008;40(11):897-904.
10. Rex DK, Petrini JL, Baron TH, et al. Quality indicators for colonoscopy. Am J Gastroenterol. 2006 Apr;101(4):873-85.
11. Cohen LB, DeLegge MH, Aisenberg J, et al. AGA Institute Review of Endoscopic Sedation. Gastroenterology. 2007;133(2):675-701.
12. Commissie kwaliteit en richtlijnen Nederlands Genootschap van artsen voor Maag- Darm- en Leverziekten. Richtlijn sedatie en /of analgesie door Maag-, Darm- en Leverartsen bij endoscopische ingrepen. http://wwwmdlnl/uploads/240/121/Richtlijn_sedatie_en_of_analgesie_door_mdl-artsen_bij_endoscopische_ingrepenpdf.
13. Cotton PB, Eisen GM, Aabakken L, et al. A lexicon for endoscopic adverse events: report of an ASGE workshop. Gastrointestinal Endoscopy. 2010;71(3):446-54.
14. Froehlich F, Thorens J, Schwizer W, et al. Sedation and analgesia for colonoscopy: patient tolerance, pain, and cardiorespiratory parameters. Gastrointest Endosc. 1997 Jan;45(1):1-9.
15. O'Connor K, Jones S. Oxygen desaturation is common and clinically underappreciated during elective endoscopic procedures. Gastrointest Endosc. 1990 May-Jun;36(3 Suppl):S2-4.
16. Lichtenstein DR, Jagannath S, Baron TH, et al. Sedation and anesthesia in GI endoscopy. Gastrointestinal Endoscopy. 2008;68(5):815-26.
17. Rozario L, Sloper D, Sheridan MJ. Supplemental Oxygen During Moderate Sedation and the Occurrence of Clinically Significant Desaturation During Endoscopic Procedures. Gastroenterology Nursing. 2008;31(4):281-5.
18. Sharma VK, Nguyen CC, Crowell MD, et al. A national study of cardiopulmonary unplanned events after GI endoscopy. Gastrointestinal Endoscopy. 2007;66(1):27-34.
19. Ristikankare M, Julkunen R, Mattila M, et al. Conscious sedation and cardiorespiratory safety during colonoscopy. Gastrointestinal Endoscopy. 2000;52(1):48-54.
20. Poon C, Leung T, Wong C, et al. Safety of nurse-administered propofol sedation using PCA pump for outpatient colonoscopy in Chinese patients: a pilot study. Asian J Surg. 2007 Oct;30(4):239-43.
21. Lee D, Chan A, Wong S, et al. The safety, feasibility, and acceptability of patient-controlled sedation for colonoscopy: prospective study. Hong Kong Med J. 2004 Apr;10(2):84-8.
22. Vargo JJ, Holub JL, Faigel DO, Lieberman DA, Eisen GM. Risk factors for cardiopulmonary events during propofol-mediated upper endoscopy and colonoscopy. Alimentary Pharmacology & Therapeutics. 2006;24(6):955-63.