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Earlier use of capsule endoscopy in inpatients with melena or severe iron deficiency anemia reduces need for colonoscopy and shortens hospital stay

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ABSTRACT
Background and study aims Capsule endoscopy (CE) is a well-established investigation for iron deficiency anemia (IDA) and melena, usually following negative upper and lower endoscopy. We aimed to study the effect of earlier CE in the investigative pathway for inpatients with IDA or melena at a large tertiary referral centre.

Patients and methods We analyzed inpatients undergoing CE for IDA or melena from 2005 to 2017, without signs/symptoms suggesting lower gastrointestinal tract pathology. Patients underwent CE following negative upper and lower gastrointestinal endoscopy (Group 1), or negative upper gastrointestinal endoscopy (UGIE) only (Group 2).

Results One hundred and seventy inpatients underwent CE for IDA (n = 44) and melena (n= 126). In Group 1, 46/95 (48.4%) patients had small bowel (SB) findings. CE found 16/95 (16.8 %) gastric and 12/95 (12.6 %) colon findings. Three of 12 patients with colon findings required repeat colonoscopy. One hundred and three colon investigations were carried out for 95 admissions. In Group 2, 33/75 (44.0%) patients had SB findings. There were 12/75 (16.0%) gastric and 11/75 (14.7 %) colon findings. In patients with positive CE, significant colonic findings led to colonoscopy in 10 of 39 patients (diagnostic yield 6/10). Thirty-six patients had negative CE; 15 underwent colonoscopy (diagnostic yield 9/15). The remaining 21 of 36 patients with no further colonoscopy did not develop adverse outcomes related to colonic pathology. Twenty-six colon investigations were carried out in 75 admissions. Patients in Group 2 had shorter mean times from admission to CE (5.08 ±3.80 vs. 6.38 ±3.80 days; P=0.02) and hospital stays (10.5 ±9.58 vs. 12.5 ±11.4 days; P=0.04) compared to Group 1.

Conclusion Earlier use of CE in inpatients with melena or IDA, no signs of lower gastrointestinal pathology and negative UGIE resulted in shortened hospital stays, significant DY from both small bowel and upper gastrointestinal tract, and two-thirds less unnecessary colon investigations without affecting clinical outcomes.

Introduction

Capsule endoscopy (CE) is well-established for investigation of small bowel bleeding [1], often presenting as iron deficiency anemia (IDA) or melena [2, 3]. CE is usually performed non-acutely as an outpatient procedure; however, there is now evidence that performing CE closer to the index bleeding episode increases its diagnostic yield (DY). Recent work suggests that in small bowel bleeding, the maximum DY for CE is achieved within the first 72 hours of presentation [4]. This is corroborated by studies showing that for the same indications, inpatient CE has a higher DY compared to outpatient procedures [5–7]. However, there is overall scarce data on inpatient use of CE (▶ Table 1).

Although current practice varies, official guidelines generally suggest performing CE in patients presenting acutely with suspected small bowel bleeding after negative upper and lower gastrointestinal endoscopy (i.e. negative bidirectional endoscopy). However, performing colonoscopy in the acute setting is a demanding task both for the patient and clinician, and is often limited by the quality of bowel preparation and patient fitness or tolerance. At our large tertiary care hospital, there has
been a trend for performing CE following a negative index upper gastrointestinal endoscopy (UGIE), with anecdotal evidence that by doing so, unnecessary colonoscopies have been avoided in certain patients. Therefore, in this large retrospective study, we aimed to examine the effect of earlier investigation with CE for inpatients with suspected small bowel bleeding manifesting as melaena or severe iron deficiency anaemia.

Patients and methods

This was a retrospective study of all inpatient CEs carried out at our tertiary care academic center from March 2005 to March 2017, using a prospectively-designed and continuously maintained database. Data collected were:
- Patient demographics: age, gender
- Relevant past medical history: cardiovascular, liver and/or renal disease; use of antiplatelet and/or anticoagulant medications; any previous episodes of gastrointestinal bleeding;
- Circumstances of admission;
- CE indications and findings;
- Timing of CE relative to admission and prior conventional endoscopies;
- Conventional endoscopies carried out within the past 6 months prior to admission;
- Further investigations and results;
- Patient outcomes, defining follow-up period as the date of last recorded patient contact with local healthcare services, discharge (back) to another health board, or death.

We analyzed inpatients undergoing CE for suspected small bowel bleeding, defined as IDA or melena in patients with negative UGIE, with no other signs or symptoms suggesting lower gastrointestinal tract pathology such as frank rectal bleeding, diarrhea with associated significant weight loss or lower abdominal pain. Over the study period, patients admitted with UGIE-negative IDA or melena underwent CE either following nondiagnostic bidirectional endoscopy (we called these patients Group 1) or following only negative UGIE (Group 2), based on the senior clinician-in-charge’s individual investigative pathways.

CE was carried out with one of two commercially-available CE systems, PillCam SB1/2 (Given Imaging Ltd, now Medtronic, Minneapolis, Minnesota, United States) or Mirosaic (Intromedic, Seoul, South Korea). Small bowel preparation was dependent on timing of CE relative to UGIE or colonoscopy, as well as the overall patient condition. In general, our center’s protocol has been to use 2L PEG, although an overnight fast alone was sometimes used for frailer patients. If CE was carried out immediately after colonoscopy, additional bowel preparation beyond the 2L PEG used for colonoscopy was not given. Simeithicone was administered with all CEs; use of prokinetics was guided by evolving practice guidelines and individual patient need [8].

Continuous data are reported as mean ± standard deviation (SD) or median (range) where appropriate. Statistical analyses were carried out and normality of distributions was tested by plotting histograms using the Analysis Toolpak in Microsoft Excel 2010 (Microsoft Corporation, Redmond, Washington, United States). For normally distributed data, Student’s t-test (when n < 30) or the Z-test (when n ≥ 30) were used to compare means, whereas the Mann-Whitney U-test was used for data where a normal distribution could not be assumed. The Chi-square test was used to compare proportions for discrete data variables. A P value < 0.05 was taken to denote statistical significance. No specific institutional ethical approval was required for this study as the data used had been collected in the course of routine patient care; ethical approval has been granted to the unit as a whole for the safe, confidential collection and storage of relevant patient information relating to CE.

Results

Over the period from March 2005 to March 2017, 170 inpatients underwent CE for suspected small bowel bleeding (104 male, 66 female; mean age 65.8 ± 17.1 years). Forty-four patients had IDA and 126 had melena. Mean hemoglobin level (Hb) at presentation was 82.8 ± 22.4 g/L. In total, there were 6 incomplete CEs; 2 were retained and required endoscopic or surgical retrieval. Median follow-up time was 31.1 months (range 0.03–121.4 months); however, it must be noted that this was a continuously maintained database and follow-up times depended on the time from CE to data collection for each patient.

Patients were divided into two groups for analysis of outcomes (Fig. 1). Group 1 comprised those with negative bidirectional endoscopy, while Group 2 included those with only negative UGIE. The groups had similar admission Hb, demographics, and medical history; they were also followed up for similar periods of time overall (Table 2). Patients in Group 2 were significantly more likely to have been admitted with melena and were also significantly more symptomatic from blood loss at the time of admission. Outcomes and further investigations carried out within the two groups are summarized in Table 3.

CE findings and outcomes: Group 1

In Group 1, there were 95 CEs carried out following negative bidirectional endoscopy. There were significant CE findings in 50 patients, i.e. 52.6%. Of these patients, 46 had SB findings; 17 of 46 patients had additional non-SB findings detected by CE in the stomach (n = 9), colon (n = 6) or both (n = 2). Another 4 patients had normal SB but colon findings seen on CE which
were deemed relevant. Forty-five patients had nondiagnostic CE following negative bidirectional endoscopy. In 31, the SB was reported as normal whereas the other 14 had nonspecific findings thought unlikely to be of clinical significance. The indication for CE was melena in 59 patients and IDA in 16. Patients with nondiagnostic CE findings were significantly more likely to have undergone CE for melaena rather than IDA, compared to patients with significant CE findings \( (P=0.03) \).

There were 12 of 75 (16.0\%) gastric findings missed by initial UGIE. Ten patients underwent repeat UGIE. Six UGIEs were done to target lesions seen on CE (3 of these were push enteroscopies to reach the duodenum). Eleven of 75 (14.7\%) patients had new colon findings; all these findings were AVMs and/or colonic bleeding. Overall in this group, 25 patients underwent colonoscopy following CE. Seven colonoscopies were done to target lesions seen on CE while the remainder were carried out in patients experiencing continued bleeding or symptoms. Fourteen of 25 colonoscopies found likely causes for the patients’ presentations; notably, one patient was found to have a colon adenocarcinoma. In the patients with negative colonoscopies, most were managed conservatively with spontaneous resolution of bleeding in six; in two patients repeat UGE found the likely sources of blood loss. One patient had CT colonography following normal CE with no cause found.

Nine patients underwent DBE to further investigate discrete lesions seen on CE \((n=3)\) or to manage continued bleeding \((n=4)\).

**CE findings and outcomes: Group 2**

In Group 2, 75 CEs were performed in patients who had negative UGIE only, with a DY of 39 of 75 (52.0\%). In the 39 patients with significant CE findings, 6 of 39 had normal SB but significant non-SB findings in the stomach \((n=2)\) and colon \((n=4)\). Of the 33 patients with SB findings on CE, 9 of 33 had additional non-SB findings in the stomach \((n=3)\), colon \((n=2)\) or both \((n=4)\). Of the 36 patients with nondiagnostic CE, the SB was reported as normal in 28. Three patients in this subgroup had additional non-SB findings (which were considered insignificant); two in the stomach and one patient with findings in both stomach and colon. The indication for CE was melena in 59 patients and IDA in 16. Patients with nondiagnostic CE findings were significantly more likely to have undergone CE for melaena rather than IDA, compared to patients with significant CE findings \( (P=0.03) \).

There were 12 of 75 (16.0\%) gastric findings missed by initial UGIE. Ten patients underwent repeat UGIE. Six UGIEs were done to target lesions seen on CE (3 of these were push enteroscopies to reach the duodenum). Eleven of 75 (14.7\%) patients had new colon findings; all these findings were AVMs and/or colonic bleeding. Overall in this group, 25 patients underwent colonoscopy following CE. Seven colonoscopies were done to target lesions seen on CE while the remainder were carried out in patients experiencing continued bleeding or symptoms. Fourteen of 25 colonoscopies found likely causes for the patients’ presentations; notably, one patient was found to have a colon adenocarcinoma. In the patients with negative colonoscopies, most were managed conservatively with spontaneous resolution of bleeding in six; in two patients repeat UGE found the likely sources of blood loss. One patient had CT colonography following normal CE with no cause found.

Nine patients underwent DBE to further investigate discrete lesions seen on CE \((n=3)\), manage SB angioectasias \((n=3)\) and further investigate/manage an area of active SB bleeding seen on CE \((n=3)\). Four patients had surgery for lesions seen on CE.

**Comparison of colon investigations per episode of gastrointestinal bleeding between the two groups**

In Group 1, a total of 103 colon investigations (colonoscopies and CT colonographies) were performed for 95 inpatient episodes of suspected small bowel bleeding, giving a rate of 1.08 colon investigations per episode. The overall diagnostic yield of
these colon investigations was 3.9%. Using the alternative approach in Group 2, 26 colon investigations were performed for 75 inpatient episodes of suspected small bowel bleeding, i.e. 0.35 colon investigations were carried out per episode. The diagnostic yield in this group was 53.8%.

Length of time between admission and CE

Examining only data from patients admitted for gastrointestinal bleeding (excluding elective admissions and patients with unrelated initial presentations who developed gastrointestinal bleeding during their hospital stay), patients in Group 2, undergoing CE following negative UGIE only, had significantly shorter mean times from admission to CE compared to patients in Group 1 (5.08±3.80 vs. 6.38±3.80 days; \( P = 0.02 \)) and shorter overall admission length (10.5±9.58 vs. 12.5±11.4 days; \( P = 0.04 \)). This was despite patients in Group 2 being more symptomatic of blood loss at the time of admission, including a greater proportion of patients displaying hemodynamic compromise when admitted (14/75 patients in Group 2 vs. 4/95 patients in Group 1; \( P = 0.002 \)).

Discussion

In this study, we found that the earlier use of CE for inpatients with melena or IDA following negative UGIE reduces the need for subsequent colonoscopy and shortens admission times. Previous data from Singh et al. [4] in a group of 144 inpatients showed that earlier use of CE (within 3 days of admission) was
associated with higher DY, rates of therapeutic intervention and decreased length of stay. Similarly, our patients who underwent CE earlier in the diagnostic pathway also had a significantly shorter mean length of stay by about 2 days ($P=0.04$). This translates to potentially significant cost savings or at least increased patient turnover and therefore capacity, especially important in large hospitals with high patient caseload.

From our experience, the reasons for the shortened length of stay in patients in Group 2 could be related to the additional time required to perform both upper and lower gastrointestinal endoscopies before making the decision to proceed to CE. Therefore, early use of inpatient CE was useful in guiding the choice of the next most appropriate route of investigation or management, as well as aiding the decision whether to proceed with these investigations and interventions urgently or following discharge. Similarly, in previous studies where CE was used acutely or semi-acutely to investigate gastrointestinal bleeding (Table 4), CE findings showed good correlation with subsequent UGIE where CE was performed as a first-line investigation before any other endoscopies [10–14]; CE carried out after endoscopic imaging was effective in directing the subsequent route of investigation [15–21].

These findings are corroborated by our study. Patients in Group 1 underwent 3.13 as many colon investigations per admission for IDA or OGIB compared to those in Group 2; however, patients undergoing CE after negative bidirectional endoscopy had a significantly shorter mean length of stay by about 2 days ($P=0.04$). This translates to potentially significant cost savings or at least increased patient turnover and therefore capacity, especially important in large hospitals with high patient caseload.

**Table 2** Comparison of patient characteristics between patients undergoing CE following negative bidirectional endoscopy and patients undergoing CE following negative UGIE only.

|                      | Group 1: CE after negative bidirectional endoscopy | Group 2: CE after negative UGIE only | $P$ value |
|----------------------|-----------------------------------------------------|--------------------------------------|-----------|
| Total number         | 95                                                  | 75                                   |           |
| M/F (%)              | 57 M (60 %)/ 38 F (40 %)                            | 48 M (64 %)/ 27 F (36 %)             | 0.59      |
| Age; years (mean ± SD) | 66.7 ± 14.6                                       | 64.7 ± 19.8                         | 0.46      |
| **PMH**              |                                                     |                                      |           |
| Liver disease (%)    | 15 (15.8)                                           | 11 (14.7)                            | 0.84      |
| Cardiovascular disease (%) | 46 (48.4)                                      | 29 (38.7)                            | 0.20      |
| On anticoagulants/ antiplatelets (%) | 37 (38.9) | 24 on anticoagulants | 17 on antiplatelets | 0.26 |
| Renal disease (%)    | 10 (10.5)                                           | 9 (12.0)                             | 0.76      |
| Previous episode/s of gastrointestinal bleeding (%) | 28 (29.5) | 24 (32.0) | 0.72 |
| **Admission details** |                                                     |                                      |           |
| Melena (%)           | 48 (50.5)                                           | 50 (66.7)                            | 0.03      |
| IDA only (%)         | 28 (30.4)                                           | 16 (21.3)                            | 0.23      |
| Other (%)            | 19 (20.0)                                           | 9 (12.0)                             | 0.16      |
| Symptomatic from blood loss (%) | 31 (32.6)                   | 38 (50.7)                            | 0.02      |
| Hemodynamic compromise at time of admission (%) (collapse, hypotension, tachycardia) | 4 (4.2) | 14 (18.7) | 0.002 |
| Admission Hb; g/L (mean ± SD) | 82.8 ± 20.7 | 82.9 ± 24.6 | 0.98 |
| Length of time from admission to CE; days (mean ± SD)$^1$ | 6.38 ± 3.80 (n=68) | 5.08 ± 3.80 (n=66) | 0.02 |
| Total length of admission; days (mean ± SD)$^1$ | 12.5 ± 11.4 (n=68) | 10.5 ± 9.58 (n=66) | 0.04 |
| Follow-up time after CE; months (mean ± SD) | 37.9 ± 31.5 | 35.8 ± 31.9 | 0.62 |

**CE** capsule endoscopy; **Hb** hematoglobin; **IDA** iron deficiency anemia; **PMH** past medical history; **SD** standard deviation

$^1$ These calculations include only data from patients admitted specifically for IDA/melena; i.e. excluding patients admitted electively or with unrelated initial presentations.

$^2$ Follow-up as recorded in electronic hospital records – i.e. until time of last recorded patient contact, discharge (back) to another health board, or death.
ever, in Group 2, use of CE earlier in the diagnostic pathway increased the DY of the resulting colonoscopies. Moreover, no adverse outcomes related to colon pathology were reported in those patients who did not have colon investigations following CE. Notably, our study reports a higher completion rate with six incomplete CEs and only two retained capsules in 170 inpatient CEs, compared to previously quoted inpatient completion rates of 50% by Dunnigan et al. [22] and 68.6% from Yazici et al. [7]. This therefore implies that in selected patients with IDA or melena, without frank rectal bleeding or other such signs or symptoms suggesting lower gastrointestinal tract pathology, CE could be used as a diagnostic or screening tool following initial UGIE. The results of CE were able to assist clinicians in determining the next most appropriate investigation, with no missed diagnoses in our group of patients.

The advantages of such an approach are appealing as a significant proportion of patients with gastrointestinal bleeding or suspected gastrointestinal bleeding have been shown to require multiple investigations. Woodward et al. conducted an analysis on the length of endoscopic workup in a large group of 451,470 patients presenting with gastrointestinal bleeding [23]. A quarter of these patients required more than one procedure to investigate and/or manage gastrointestinal bleeding, with an average of 2.4 procedures per patient. In particular, patients with anemia were the least likely to be managed with a single procedure, with 20% and 21% of these patients requiring further UGIEs and colonoscopies, respectively. Similarly, in a 2015 study, Sonnenberg modelled test sequences in patients with gastrointestinal bleeding, and found an average of 2.7 procedures performed per patient, with a significant 5% of patients requiring more than six procedures [24].

An alternative approach to CE is for patients with ongoing gastrointestinal bleeding to undergo repeat UGIE and colonoscopy; this would be supported by the incidence of “missed” upper and lower gastrointestinal findings seen in our group. This approach is in line with work by Fry et al. [25], but on the other hand, is not suggested by the current guidelines, and would be limited by increased investigative burden and poor patient acceptability. Furthermore, the current convention of performing colonoscopy before CE is based on older, possibly now less-supported data that suggest the small bowel is the bleeding source in 10% of gastrointestinal bleeding [26]. With the technological advances now available, we would suggest that the increasing accessibility of CE as a diagnostic tool is combined with com-

### Table 3: Investigations and management in our group of inpatients with IDA/melena.

| Group 1: CE following -ve bidirectional endoscopy | Group 2: CE following -ve UGIE only |
|-----------------------------------------------|-------------------------------------|
| **CE findings** | **-ve CE** | **+ve CE** | **-ve CE** |
| Number of patients (%) | 50 (52.6) | 45 (47.4) | 39 (52.0) | 36 (48.0) |
| Incomplete CEs (%) | 3 (3.2) | 3 (4.0) | |
| **UGIE and colonoscopy** | | | |
| Missed findings on initial UGIE (%) | 11 (22.0) | 5 (11.1) | 9 (23.1) | 3 (8.3) |
| Missed findings on initial colonoscopy (Group 1) (%) | 12 (24.0) | NA | |
| Colon findings on CE (Group 2) (%) | NA | 10 (25.6) | 1 (2.8) |
| Repeat UGIEs (%) | 6 (12.0) | 4 (8.9) | 9 (23.1) | |
| Total number of colon procedures/Ix carried out | Initial colonoscopy: 50 Repeat colonoscopy: 4 CT colon: 1 Total: 55 | Initial colonoscopy: 45 Repeat colonoscopy: 2 CT colon: 1 Total: 48 | Initial colonoscopy: NA Colonoscopy: 10 CT colon: 0 Total: 10 | Initial colonoscopy: NA Colonoscopy: 15 CT colon: 1 Total: 16 |
| Total burden of colon Ix | 103 colon Ix for 95 episodes | 26 colon Ix for 75 episodes |
| Diagnostic yield of colon Ix | 3.9% (4/103) | 53.8% (14/26) |
| **Other Ix and/or management following CE** | | | |
| DBE (%) | 7 (14.0) | | 9 (23.1) | |
| CT angiography (%) | 5 (10.0) | 3 (6.7) | 1 (2.6) | 2 (5.6) |
| Repeat CE (%) | | | | 2 (5.1) |
| Surgery (%) | 5 (10.0) | | 4 (10.3) | |

- ve negative; + ve positive; CE capsule endoscopy; DBE double balloon enterography; Ix investigations; SD standard deviation; UGIE upper gastrointestinal endoscopy
Table 4  Summary of previous studies on use of CE in the acute to semi-acute setting.

| Authors, Year | Type of study | No. of patients (completion rate) | CE model | Indications for CE | Ix before CE | Time to Ix | Positive CEs | Management of positive CEs | Negative CEs | Management of negative CEs | Follow-up period and outcomes |
|---------------|---------------|----------------------------------|----------|-------------------|--------------|-----------|-------------|---------------------------|--------------|--------------------------|-----------------------------|
| Leclerc et al., 2012 [15] | Retrospective, single center | 55 (100%) | PillCam M2A and SB | Melena, hematochezia, hemodynamic instability, >2 units RCC transfused | Negative bidirectional endoscopy | CE within 48 h of negative bidirectional endoscopy | 49 | Endoscopy: 30 (26 PE/DBE) Surgery: 12 Conservative: 7 | 6 | Interventional radiology: 1 Conservative: 5 | 36 months 6 patients rebled |
| Rauf et al., 2014 [16] (abstract) | Single center | 25 (100%) | NS | Acute OGIB | Negative bidirectional endoscopy | NS | 24 | APC: 5 Surgery: 4 Conservative: 16 | 1 | NS | NS |
| Ponte et al., 2015 [18] (abstract) | Single center | 42 (100%) | NS | Active overt OGIB, persistent melena/ hematochezia, hemodynamic instability, >2 units RCC transfused | Negative bidirectional endoscopy | CE within 48 h of negative bidirectional endoscopy | 38 | Targeted treatment/ management in 31 patients | 4 | NS | NS |
| Perez-Cuadrado Robles et al., 2015 [19] | Retrospective, single center | 16 (100%) | PillCam SB | Hematemesis, hematochezia, melena | Negative bidirectional endoscopy; other negative investigations: 8 DBE, 3 PE, 12 CE, 21 radiological imaging | All patients proceeded to DBE following CE, within 48 h of presentation | 16 | All underwent DBE: CE changed approach in 3 patients (DY 16/16) | 0 | – | NS |
| Schlag et al., 2015 [17] | Prospective, single center | 20 (95 %) | PillCamSB2 | Melena or dark red stools, hemodynamic instability, Hb drop >2 g/dL, transfusion >2 units RCC/day (Excluded: hematemesis, fresh rectal bleeding) | UGIE only | 9.8h to UGIE (mean) | 15 | Enteroscopy: 10 Surgery: 1 Colonoscopy: 4 (DY 3/4) | 4 | Colonoscopy (DY 3/4) | 4 weeks 1 death (cardiac), 1 readmission (diverticular bleed) |

Studies where CE was used as first-line investigation for bleeding

| Authors, Year | Type of study | No. of patients (completion rate) | CE model | Indications for CE | Ix before CE | Time to Ix | Positive CEs | Management of positive CEs | Negative CEs | Management of negative CEs | Follow-up period and outcomes |
|---------------|---------------|----------------------------------|----------|-------------------|--------------|-----------|-------------|---------------------------|--------------|--------------------------|-----------------------------|
| Graheket al., 2013 [10] | Prospective, multicenter | 47 (97.9%) | PillCam ESO2 | Hematemesis and/or melena in past 48 h (Excluded: unstable patients; fresh hematemesis) | None | CE within 12 – 24 h | 31 | UGIE (DY 27/31) | 15 | UGIE (DY 12/15) | NS |
| Authors, Year          | Type of study       | No. of patients (completion rate) | CE model   | Indications for CE                                                                 | Ix before CE | Time to Ix | Positive CEs | Management of positive CEs | Negative CEs | Management of negative CEs | Follow-up period and outcomes |
|------------------------|---------------------|-----------------------------------|------------|------------------------------------------------------------------------------------|--------------|------------|--------------|----------------------------|--------------|-----------------------------|-----------------------------|
| Gutkin et al., 2013    | Prospective, single center | 12 (100%)                          | PillCam ESO2 | Melena, hematemesis, hemodynamic instability (Excluded: Hematemesis <2h before presentation, too unstable) | None         | NS         | 8            | 4 UGIE (DY 8/8) | 4  | UGIE (DY 1/8) | No high-risk stigmata seen                                      |
| Meltzer et al., 2013   | Prospective, single center | 24 (100%)                          | PillCam ESO2 | Melena, hematemesis (Excluded: Hemodynamic instability)                              | None         | NS         | 11           | 8 UGIE (DY 7/11) | 8  | UGIE (DY 1/8) | No complications                                                      |
| Chandran et al., 2013  | Prospective, multicenter | 83 (100%)                          | PillCam ESO | Melena, hematemesis (Excluded: too unstable)                                         | None         | 15 h to CE (median) | 41           | 42 UGIE (DY 41/41) | 42 | UGIE (DY 2/42) | NS 4 patients rebled                                              |
| Sung et al., 2016      | Prospective, single center | 34 (100%)                          | PillCam ESO2 | Coffee ground vomit, melena (Excluded: fresh hematemesis, hemodynamic instability) | None         | NS         | 7            | 27 UGIE (DY 7/7) | 27 | UGIE No significant findings | 30 days No rebleeding, 1 patient with negative CE later had gastric ulcer |
| Dunn et al., 2014      | Retrospective, single center | 127 (100%)                         | NS         | All urgent CE referrals                                                              | NS          | NS         | 57           | NS                         | 70 | NS             | NS                          |
| Omote et al., 2014     | Retrospective, single center | 35 (100%)                          | NS         | Acute overt OGIB                                                                    | NS          | NS         | 21           | Enteroscopy: 10 | 14 | NS             | NS No severe complications                                    |

CE capsule endoscopy; DBE double balloon enteroscopy; DY diagnostic yield; PE push enteroscopy; RCC red cell concentrate; UGIE upper gastrointestinal endoscopy
prehensive clinical assessment to ensure an appropriate and timely choice of investigation for patients with gastrointestinal bleeding.

Limitations of this study stem largely from its retrospective design including missing data, dependence on good prior recordkeeping and the possible effects of advances in CE technology since its introduction to clinical practice. However, although image quality may have improved over the study period, the main finding of concern in patients with gastrointestinal bleeding is localization of blood within the gastrointestinal tract rather than detailed lesion definition; this is an obvious finding where technological improvement may not have had as great an impact. Furthermore, our center’s data date from 2005, when CE had already been approved for conventional clinical use, with acceptable image quality from the first models which we had used. Similarly, our center had started using PEG for bowel preparation at an early stage, almost from the beginning of the capsule service, even though official guidelines had not been standardized then; most of the patients in our group received similar bowel preparation throughout the study period.

Another limitation stemming from the retrospective study design is that choice of investigative pathway and CE timing in our patients was determined by consultant preference. Despite this, the demographics and admission data suggest that the two groups were comparable. Given that melena was more often the indication for CE in Group 2, our results would also suggest that such patients with melena and negative UGIE are more likely to benefit from earlier use of CE. Although this approach seems logical, in routine clinical practice, most centers currently reserve use of CE until a negative colonoscopy has occurred. Furthermore, and despite the recognized disadvantages of a retrospective study, such a study has the benefit of a large patient group, longer follow-up times and accurate reflection of “real world” experience.

Conclusion

In conclusion, inpatient CE for IDA or melena had a diagnostic yield of 52.3% at our center. In such patients, use of CE earlier in the investigative pathway significantly reduced the number of colonic investigations performed without compromising clinical outcomes. This has the potential to improve the patient experience by reducing the number of negative invasive procedures. We found that earlier use of CE also shortened hospital stays. Our findings inspire confidence in earlier use of CE in inpatients with IDA or melena in the absence of signs and symptoms suggestive of colonic pathology.

Competing interests

None

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