

Accepted Manuscript

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PII: S1542-3565(17)30466-4
DOI: [10.1016/j.cgh.2017.04.023](https://doi.org/10.1016/j.cgh.2017.04.023)
Reference: YJCGH 55208

To appear in: *Clinical Gastroenterology and Hepatology*
Accepted Date: 14 April 2017

Please cite this article as: Tan M, Lahiff C, Bassett P, Bailey AA, East JE, Efficacy of Balloon Overtube-assisted Colonoscopy in Patients With Incomplete or Previous Difficult Colonoscopies: a Meta-analysis, *Clinical Gastroenterology and Hepatology* (2017), doi: 10.1016/j.cgh.2017.04.023.

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TITLE

Efficacy of Balloon Overtube-assisted Colonoscopy in Patients With Incomplete or Previous Difficult Colonoscopies: a Meta-analysis

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Disclosures

Dr. East: Clinical Advisory Board, Lumendi Limited; Research support, Olympus. All other authors have no conflicts disclosures to make.

AUTHOR INVOLVEMENT

Malcolm Tan: study concept and design; acquisition of data; analysis and interpretation of data; drafting of the manuscript; administrative,

Conor Lahiff: study concept and design; acquisition of data; analysis and interpretation of data; administrative,

Paul Bassett: analysis and interpretation of data; statistical analysis;

Adam Bailey: study concept and design; administrative, study supervision

James E East: study concept and design; acquisition of data; analysis and interpretation of data; drafting of the manuscript; critical revision of the manuscript for important intellectual content; statistical analysis; administrative, study supervision

Keywords: Colonoscopy; single-balloon enteroscopy; double-balloon enteroscopy; colorectal cancer; intubation; colonic polyps; systematic review

Abbreviations

BOAC, balloon overtube assisted colonoscopy

CIR, caecal intubation rate

CRC, colorectal cancer

DBE, double balloon enteroscopy

MEI, magnetic endoscope imaging

SBE, single balloon enteroscopy

TTC, time to caecum

INTRODUCTION

Colonoscopy is an effective tool to diagnose and treat colorectal conditions. Caecal intubation rates (CIR) of $\geq 95\%$ for screening and $\geq 90\%$ for all colonoscopies have been advocated as measures for good quality colonoscopy (1). Factors associated with failed colonoscopy include older age, female gender and previous abdomino-pelvic surgeries (2). Options for previously failed colonoscopy include using a smaller calibre endoscope, water-assisted, cap-assisted, magnetic endoscope imaging (MEI), and balloon overtube assisted colonoscopy (BOAC).

We sought to systemically evaluate the literature on the utility of BOAC in patients with previous incomplete standard colonoscopy.

METHODS

The primary outcome for our analysis was CIR. Secondary outcomes included time to caecum (TTC), endoscopic findings, complications and comparison between single (SBE) and double balloon enteroscopes (DBE). (PROSPERO 2016: CRD42016048359)

Studies published between January 2001 and June 2016 were suitable for our review if they met the following criteria: 1) Fully published in English language journals; 2) BOAC was performed in patients with previous incomplete colonoscopies; 3) CIRs, endoscopic findings and complications were reported; 4) cohort studies or randomized controlled trials.

Studies were pooled using meta-analysis methods with fixed effect models if heterogeneity was low ($<50\%$) and random effects models otherwise.

RESULTS

A total of 1251 papers were identified. Eighteen suitable studies were included in our analysis.

Fourteen were uncontrolled studies in which BOAC was attempted in patients who had previously failed colonoscopies, one study compared SBE to repeat standard colonoscopy, one compared DBE to MEI colonoscopy, and two studies compared SBE with DBE. Fluoroscopy was used in 11 studies.

The total number of patients in the studies was 667. In 629 patients for which the patient's gender was reported, 336 (53.4%) were female. The average age was 66.1 years (range: 18-91). Eight studies reported that 171/375 (45.6%) patients had a history of abdomino-pelvic surgery. The top three primary reasons for failure of standard colonoscopy were: excessive looping ($n=246$); a fixed sigmoid ($n=117$); pain ($n=114$).

The pooled CIR for BOAC was 97% (95% CI: 95-99%), with a small amount of heterogeneity ($I^2=4\%$, $p=0.40$). between studies. The mean TTC was 21 minutes (95% CI: 18-24), with considerable heterogeneity ($I^2=93\%$, $p<0.001$), Figures 1A and 1B. There was little evidence of publication bias for CIRs, but the funnel plot for TTC suggests that studies with longer TTC were more likely to be published,

Figures 1C and 1D. Restricting the analysis to studies with ≥ 20 patients did not significantly change the results.

There was no difference between SBE and DBE when CIR (98% vs 97%, $p=0.63$) and TTC (22 vs 19 minutes, $p=0.40$) were compared.

Significant additional colonic pathologies that were found after BOAC included colorectal polyps ($n=325$), colorectal cancer ($n=18$) and inflammatory bowel disease ($n=9$).

There were no complications attributed to the technique of BOAC.

DISCUSSION

BOAC achieved a CIR of 97% in patients with challenging colons, which is in line with recommendations of achieving a rate of $>90\%$. In one study, an inexperienced trainee with a prior CIR of 60% managed to achieve 100% CIR with a median time of 16 minutes, therefore BOAC may not be technically demanding (3). SBE and DBE had similar outcome. The success of BOAC appears to be dependent on the overtube balloon which allows for the colon to be gripped and pleated to facilitate advancement.

Additional pathologies were seen when the patients returned for BOAC. In total an additional 325 colorectal polyps and 18 malignancies (2.7%) were discovered in our 667 patients, comparable to Neerincx et al who showed a second examination, which included a repeat colonoscopy or imaging, uncovered colorectal cancer (3.5%) and advanced neoplasia (4.3%) in 511 patients (4).

Water aided techniques have been described to be promising alternatives to standard colonoscopy (5). Magnetic endoscope imaging (MEI) is an adjunctive tool that has been shown to improve CIRs (6). Two studies underscore the effectiveness of BOAC in patients who failed repeat standard colonoscopy and MEI assisted colonoscopy (7, 8).

The strengths of our systemic review include the large number of patients ($n=667$) and centres ($n=18$) available suggesting the result may be generalizable to the wider endoscopic community, with narrow confidence interval and low heterogeneity of the pooled CIR estimate, and no suggestion of publication bias. A limitation was that most papers were uncontrolled studies that evaluated the use of BOAC without a comparator.

In conclusion, BOAC is a safe and effective option for patients who have previously failed standard colonoscopy and should be considered as a first option for technically difficult colonoscopy where available, offering advantages over radiological alternatives because of high neoplasia yield and therapeutic capabilities BOAC should be routinely available as a "rescue" technique in major endoscopy units.

Figure 1. 1A. Forrest plots for caecal intubation rate (fixed effect model), 1B. Time to caecum (random

effects model); 1C. Funnel plots to assess publication bias for caecal intubation rate, and 1D. Time to caecum (D). May (Endoscopy 2006;38:395-8), Kaltenbach (Digestive & Liver Disease. 2006;38:921-5), Akahoshi (World J Gastroenterol. 2006 Dec 21;12(47):7654-9), Gay (Endoscopy. 2007 Sep;39(9):788-92), Pasha (Gastrointest Endosc. 2007 May;65(6):848-53), Mönkemüller (Scand J Gastroenterol. 2007 Feb;42(2):277-8), Moreels (J Gastroenterol Hepatol. 2010 Jan;25(1):80-3), Teshima (Gastrointest Endosc. 2010 Jun;71(7):1319-23), Hotta (Gastrointest Endosc. 2012 Apr;75(4):813-8.), Arai (J Interv Gastroenterol. 2012 Jan;2(1):12-14), Kobayashi (World J Gastrointest Endosc. 2013 Mar 16;5(3):117-21), Nemoto (Dig Endosc. 2014 May;26(3):392-5), Becx (Eur J Gastroenterol Hepatol. 2014 May;26(5):519-22), Sulz (Surg Endosc. 2016 May;30(5):1876-82), Keswani (Gastrointest Endosc. 2011 Mar;73(3):507-12), Suzuki (Endoscopy. 2012 Jan;44(1):38-42), Dzeletovic (Dig Dis Sci. 2012 Oct;57(10):2680-6), Yamada (World J Gastroenterol. 2013 Aug 7;19(29):4732-6).

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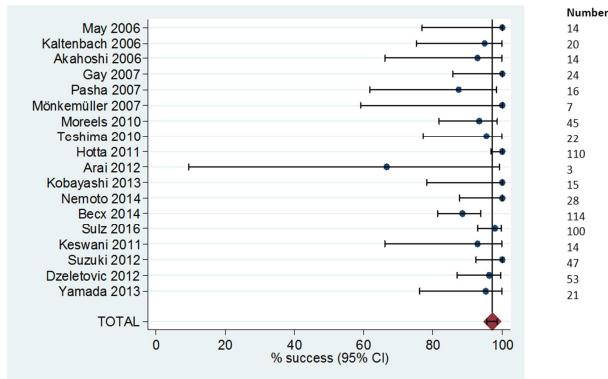
Acknowledgements

We are grateful for the support of the librarians at the University of Oxford who assisted with developing the systematic search strategy for this analysis.

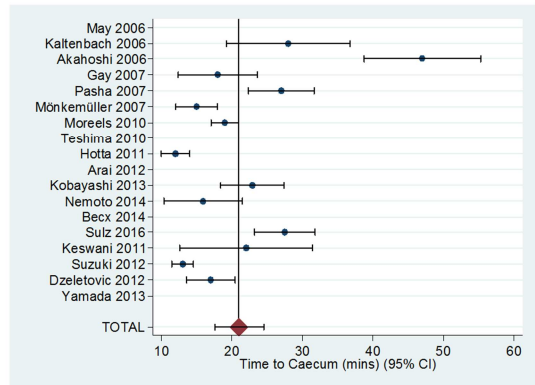
Funding

Dr. James East and Dr. Adam Bailey are funded by the Oxford NIHR comprehensive Biomedical Research Center

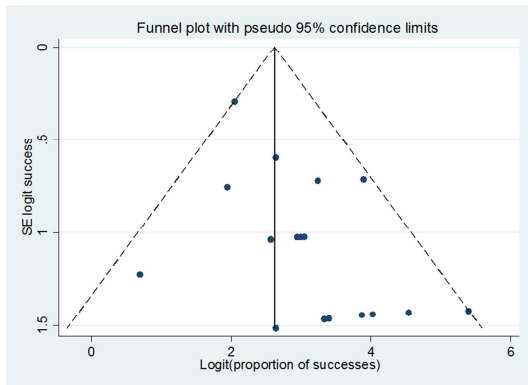
A



B



C



D

