
ORIGINAL ARTICLE

Cost-effectiveness Analysis of Protocol-driven Barium Enema Performed by Radiographers

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ABSTRACT

Objective: To assess the cost-effectiveness of protocol-driven barium enema performed by radiographers compared with that performed by radiologists.

Methods: This was a retrospective review of 248 consecutive patients undergoing barium enema between January 2006 and February 2008. 173 barium enemas were performed by radiographers and 75 by radiologists. The degree of colonic visualisation for each group was analysed. The screening time and total dose product (Gy/cm²) for the examination were recorded. The number of films, contrast volume, and number of staff for each group were included in the estimation of the cost of the examination.

Results: Sufficient visualisation to be of diagnostic value was achieved by 93.6% of barium enemas performed by radiographers and 100% of those performed by radiologists. There was no statistically significant difference in consumption of barium and films, screening time, and total dose product ($p > 0.05$). The manpower for barium enema examination decreased by 40%, the productivity increased by 67%, and the estimated cost decreased by 37% when performed by a radiographer compared with a radiologist.

Conclusions: The cost of protocol-driven barium enema performed by radiographers was significantly reduced without decreasing quality or increasing the radiation dose for patients. Protocol-driven barium enema performed by radiographers is a cost-effective method of enhancing productivity and efficiency for the radiology services.

Key Words: Barium sulfate; Cost-benefit analysis; Enema

INTRODUCTION

Protocol-driven barium enema (PDBE) performed by radiographers in North District Hospital, Hong Kong, started in January 2006. The radiographers now perform most of the barium enemas at the hospital.

Protocol-driven examinations can reduce radiologists' workloads, and redistribute manpower for more specialised and complex procedures. Chalmers et al suggested that experienced nurses and radiographers could rapidly acquire the skills to perform diagnostic angiography safely and efficiently.¹ Boulton et al also suggested that specialist nurses with appropriate experience can be trained to perform standard transfemoral cardiac

catheterisation procedures safely and competently for low risk patients.² Studies have suggested that radiographers have an important role in the preliminary interpretation of chest radiographs in a cardiothoracic unit³ and following mammography.⁴ A study by Ng et al has also suggested that it is cost-effective for radiographers to perform protocol-driven intravenous urogram examinations with no degradation of quality.⁵ However, there has been no study to analyse the cost effectiveness of barium enema examinations performed according to a protocol without a radiologist present in Hong Kong. This study was performed to assess the cost-effectiveness of PDBE performed by radiographers. The diagnostic value of the barium enema examinations, screening times, and total dose product were also analysed.

METHODS

Patients

The medical records of patients undergoing barium enema examinations between January 2006 and February 2008

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were retrospectively reviewed. 248 patients were recruited (126 men, 122 women). 173 PDBEs were performed by radiographers and 75 non-protocol-driven barium enemas (NPDBEs) were performed by radiologists. The barium contrast Polibar ACB (E-Z-EM; Canda Inc, New York, USA) 500 mL was used for each patient. The examination was performed using an image intensifier (Philips Diagnost 76 plus; Philips Medical System, Eindhoven, The Netherlands). Patients underwent bowel preparation using Klean-prep (Helsinn Birex Pharmaceutical Ltd, Edgware, UK) before the examination. The number of films, volume of barium, screening time, and total dose products were recorded.

Design

The PDBEs were performed by a team of well-trained and experienced radiographers. A radiologist working near the barium enema examination room was on standby for any medial emergency. A nurse was responsible for rectal tube insertion and a radiographer was responsible for barium introduction and filming according to the protocol. Additional films were performed if indicated. All films were reported by radiologists. The average experience of the radiographers and radiologists were both more than 5 years. The radiographers had been trained by radiologists, during which time they had to perform 10 PDBEs under direct supervision and 10 under indirect supervision, and needed to pass an assessment before being given approval to perform barium enemas. Table 1 shows the procedures for PDBE and NPDBE.

Other safety measures were enforced for the PDBE group, including table tilt no greater than 10° and no administration of intravenous buscopan. Manual per rectal air pumping was performed under fluoroscopic screening, which would be stopped when the colon was optimally distended or if the patient experienced discomfort.

Table 1. Procedures for protocol-driven and non-protocol-driven barium enema.

Protocol-driven barium enema	Non-protocol-driven barium enema
Preliminary film	Preliminary film
Supine film	Supine film
Prone film	Prone film
Right decubitus film	Right decubitus film
Left decubitus film	Left decubitus film
Erect film	Erect film
Lateral rectum film	Lateral rectum film
Prone caudal film	Prone caudal film
± Oblique film*	± Localised view [†]

* The necessity for oblique views was decided by the radiographer.

[†] The necessity for localised views was decided by the radiologist.

Patients were selected based on age (younger than 60 years), ambulation, and no previous history of abdominal operation.

The barium enema films were reviewed by 2 radiologists (with 11 and 6 years' experience) who agreed on the results. The quality of the examination was classified as follows:

- complete colonic visualisation sufficient for diagnostic value
- incomplete colonic visualisation, due to inadequate barium coating, colonic distension, or overlapping bowel shadows.

The screening time and total dose product (Gy/cm²) were also compared. The number of staff, films, and amount of barium usage for each group were included in the cost of each examination. The mid-points of the Hospital Authority pay scale for radiographers and radiologists were used for comparison. The number of days for reporting the results between the groups were also compared.

Statistical Analysis

Significance levels were presented as p values, whereby a p value <0.05 was considered statistically significant. Unpaired *t* test was used to assess the significance level between the groups.

RESULTS

The mean age of the patients was 46.8 years, with ranges of 20 to 60 years for the PDBE group and 20 to 80 years for the NPDBE group. In the PDBE group, sufficient colon visualisation to be of diagnostic value was achieved for 163 of 174 patients (93.7%); 11 patients (6.3%) had inadequate colon visualisation, including 7 due to overlapping of bowel loops in the hepatic and splenic flexures and 4 due to segments of non-distended colon. No patients had inadequate colon visualisation due to insufficient barium coating. In the NPDBE group, all patients showed adequate colonic visualisation. Additional localised views of the colon and air pumping were performed by radiologists during real-time screening.

Table 2 shows the volume of barium, number of films used, the screening time, and total dose product for the PDBE and NPDBE groups. Table 3 shows the estimated cost of each barium enema examination for the 2 groups (excluding the cost of the machines and film processing). There were no significant differences ($p > 0.05$) in

Table 2. Comparison of parameters for protocol-driven barium enema (PDBE) and non-protocol-driven barium enema (NPDBE) examinations.

Parameter	PDBE	NPDBE
Average volume of contrast per examination (mL)	100	100
Average number of films per examination	8.6	8.7
Average screening time (seconds)	303	304
Average total dose product (Gy/cm ²)	36.9	38.8

Table 3. Comparison of the average estimated cost of each protocol-driven barium enema (PDBE) and non-protocol-driven barium enema (NPDBE) examination (excluding the cost of the machine and film processing).

Expense	PDBE (HK\$)	NPDBE (HK\$)
Radiologists	\$84.50	\$422.50
Radiographers	\$177.60	\$177.60
Nurses	\$133.70	\$133.70
Contrast medium	\$128.80	\$128.80
Films	\$60.20	\$60.90
Total	\$584.80	\$923.50

the volume of barium, number of films used, screening time, or total dose product.

Using PDBE, radiologists can now report 10 barium enema examinations in a morning session (4 hours) and 7 in an afternoon session (3 hours), compared with 6 examinations in a morning and 4 in an afternoon without PDBE. The mid-point of the Hospital Authority pay scales for radiographers, nurses, and radiologists was used for the calculation of the estimated cost of the staff for each examination. The number of films for each group and the volume of contrast used were also included in the final estimation of the cost. Each PDBE examination was estimated to cost HK\$584.80 while each NPDBE examination cost HK\$923.50. There was, therefore, a 37% reduction in cost for each examination using PDBE. However, the average reporting time increased for PDBE (10 days) when compared with NPDBE (2 days).

There was no extravasation or bowel perforation during the PDBE examinations. No complaints were received from the patients.

DISCUSSION

More than 200,000 barium enema examinations are performed annually in the UK, representing a significant workload for radiologists. The PDBE performed by radiographers has proved successful in the USA and UK.^{6,7} Experienced radiographers have been performing barium enemas at the North District Hospital since 2006 and are currently performing the majority of the outpatient barium enemas. PDBE can reduce the

radiologists' workloads and redistribute the manpower for more specialised or complex procedures.

Barium enema can be performed by a radiographer and reported later by a radiologist, making it more efficient and cost-effective. In this study, the volume of barium, number of films, screening time, and total dose products used by each group showed no significant difference. Therefore, there was no additional radiation dose to the patients and no additional costs for the protocol-driven examination. Only a few examinations resulted in inadequate colonic visualisation among patients in the protocol-driven group. These examinations could be improved by additional views (oblique or localised) and air pumping, if decided by the radiographers. At the North District Hospital, the protocol has been revised to include 2 additional erect oblique views for the hepatic and splenic flexures. The initial results have been excellent and no further suboptimal visualisation has been noted. However, further evaluation will be needed in the future.

Each PDBE examination was estimated to cost HK\$584.80, while each NPDBE examination cost HK\$923.50. The estimated cost of each PDBE examination was reduced by 37%, with the major contribution being the radiographers' salary. Since the introduction of PDBE, radiologists can report 85 examinations per week, compared with 50 examinations before the introduction of PDBE. The productivity for PDBE examination has increased by 70%. Moreover, reporting on several barium enemas can be done at one time to allow more flexible allocation of work in the department. Given these circumstances, the radiologists workload for PDBE examination decreased by 40% and the manpower was redistributed to provide value-added services such as magnetic resonance imaging and computed tomography, and more specialised procedures, including interventional radiology. The waiting time for a barium enema examination decreased from 6 months to 2 months after PDBE was implemented.

The average reporting time increased from 1 to 2 days to approximately 10 days. This was mainly due to the increased time required for film distribution for reporting. However, the delay was acceptable as only elective patients underwent PDBE and there was no delay to the follow-up consultation.

The limitations of this study included the enrollment of patients who were younger than 60 years and were ambulatory into the PDBE group. Intravenous buscopan

was not given for the PDDBE group in view of potential side effects, while radiologists in the NPDBE group usually give buscopan to enhance the spasmolytic effect unless there are any contraindications. However, this reflects the situation in clinical practice.

This study found that the cost of barium enema is significantly reduced when performed by radiographers, without compromising quality or increasing the radiation dose to patients. Barium enema performed by radiographers is cost-effective and enhances the productivity and efficiency of the radiology services.

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