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Barium Enema

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UTILIZATION, COSTS, AND CONTROVERSIES

Barium enema (BE) is a generic term referring to radiological studies of the colon and rectum using contrast materials. The conventional procedure, sometimes called a single-contrast enema (SCE), consists of fluoroscope-guided radiography of the colon while it is filled with a barium contrast solution. The double-contrast enema (DCE) is performed while a thin layer of contrast solution coats the colon lining and air is insufflated into the colon. The purpose of the BE examination is to detect diseases of the colon, principally colitis, regional enteritis, diverticulitis, polyps, and carcinoma.

In 1970, an estimated 3.5 million BE examinations were performed in the United States. About 80 percent were performed in hospital settings (31). The examination involves a high radiation dose because of the multiple views and the need for fluoroscope to localize the spot

films. It is estimated that in 1970, there were an average 3.9 films per examination. As might be expected, because of the direct exposure of the gonads to primary beam irradiation, the BE has a higher gonad dose for both sexes than do the chest and skull exams. For males, this dose is 22 millirads per exam (a medium dose); for females it is 574 millirads. For females, only the lumbar spine exam results in a higher gonadal exposure (28).

Of all physicians, radiologists predominate in the administration of BE regardless of the setting in which they are performed. Tables 10 and 11 present data on the California medicaid claims for BE examinations. In California in 1978, 97.8 percent of all physicians' claims for BE to the medicaid program were filed by radiologists. Virtually 100 percent of all physicians' claims for BE on inpatients and outpatients were submitted

Table 10.—Medicaid Barium Enema Claims in California Submitted by Physicians in First Quarter of 1978, by Location of Service

	Inpatient ^a	Outpatient ^a	Office	Other	Total
74270 Colon: barium enema.....	688 (89.9%)	1,227 (95.6%)	4,050 (84.0%)	61 (100%)	6,026 (82.0%)
74275 Colon: combined with air contrast.....	62 (08.1%)	25 (01.9%)	694 (14.4%)	—	781 (11.3%)
74280 Colon: air contrast.....	15 (02.0%)	31 (02.4%)	75 (01.6%)	—	121 (01.7%)
Total.....	765	1,283	4,819	61	6,928

^aRecorded only when hospital and physician bill separately for the service (split billing arrangement).

SOURCE Urban Institute 1980. Sample of 5000 solo practitioners including 177 radiologists

Table 11.—Medicaid Barium Enema Claims in California Submitted by Radiologists in First Quarter of 1978, by Location of Service

	Inpatient ^a	Outpatient ^a	Office	Other	Total
74270 Colon: barium enema.....	636 (89.2%)	1,206 (85.2%)	3,141 (83.9%)	57 (100%)	5,040 (84.50%)
74275 Colon: combined with air contrast.....	62 (08.7%)	213 (15.1%)	545 (14.6%)	—	820 (13.8%)
74280 Colon: air contrast.....	15 (02.1%)	31 (02.2%)	56 (01.5%)	—	102 (01.7%)
Total.....	713	1,415	3,742	57	5,962

^aRecorded only when hospital and physician bill separately for the service (split billing arrangement).

SOURCE Urban Institute, 1980. Sample of 177 radiologists (32.6 percent of solo radiologists in California).

by radiologists; almost 97 percent of claims for BE examinations in physicians' offices were made by radiologists. *

The conventional SCE is much more frequent than the more involved double contrast or combined studies. MacEwan reported that in Canada's Manitoba Province in 1974, 95 percent of all BEs were SCEs (77). California medicaid claims data from a sample of approximately 5,000 solo practitioners substantiate the dominance of the conventional examination over DCE but reveal a slight decline in its proportionate use from 1973 to 1978.** In this sample of physicians, SCE exams accounted for 86.2 percent of BE procedures performed in physicians' offices in 1973; by 1978, this proportion had diminished slightly to 84.1 percent. The relative proportion of conventional BE to air-contrast procedures decreased more appreciably in other settings. From 1973 through 1978, the use of SCE examinations declined from 96 to 89 percent in inpatient settings, and from 94.5 to 83 percent in hospital outpatient settings. An earlier survey of leading institutions and practitioners found a similar trend. The number of radiologists using only the DCE increased between 1966 and 1968 (84).

BE is a complicated procedure for both the patient and physician. Adequate preparation of the patient to insure complete evacuation of fecal matter must precede the application of the contrast enema. This preparation usually involves dietary restriction for 1 to 2 days, administration of cathartics, and cleansing enemas (82). Inadequate or hasty patient preparation seriously compromises the ability to diagnose accurately (82,91).

The radiologist is faced with numerous other choices in technique, ranging from patient positioning to methods for compressing the colon. One textbook states that "probably no two radiologists perform the barium enema in exactly the same way, [but] opinion and practice on most of the important steps of the examination are amazingly uniform" (82).

The importance of radiological method, particularly patient preparation, to the success of the BE implies high variation in diagnostic efficiency among physicians and facilities. This variation presents an important evaluative dilemma. If the procedure does not perform well in a study, critics are quick to argue that radiological technique was inadequate (3). If BE is not evaluated at its best, physicians will be loathe to accept study findings, in the belief that the performance in their own institutions will surpass that of the study. However, evaluating performance of the BE only in the best centers, as advocated by some (3,72), may overestimate its general value as a diagnostic tool.***

BE is well established as the mainstay of diagnostic methods in the colon (59). The development of flexible fiberoptic endoscopy of the colon (colonoscopy) in the past decade has increased the ability to detect certain diseases of the colon, but the high cost of colonoscopy relative to BE and the general reliance of colonoscopists on prior BE films to guide their own examinations imply that the BE will not be replaced by endoscopy to any significant degree in the foreseeable future (92). Indeed, the potential for conflicting findings on the two examinations may lead to increasing numbers of followup X-ray procedures.

In recent years, investigators have used the findings of colonoscopy to assess the sensitivity of BE in detecting polyps and carcinomas of the colon. Prior to the availability of colonoscopy, the sensitivity of BE could only be surmised, since there was no independent method for demonstrating false negatives from BE. Now, at least some tumors and polyps not found on BE have been found by colonoscopy. The results of these studies of the diagnostic efficiency of BE and colonoscopy are discussed later in this section.

At present, radiologists disagree about whether and where the DCE should be used instead of, or in addition to, the single-contrast procedure (69,83). The choice between the SCE and the DCE is important for medical cost and radiological risk. The DCE examination is gen-

*Urban Institute, unpublished data, 1980.

* ● Urban Institute, unpublished data, 1980

* ● This general issue of "efficacy" v. "effectiveness" has been discussed elsewhere (97).

erally more time consuming than the SCE and requires careful patient preparation. If both procedures are performed, costs and radiation exposure to the patient are almost doubled. The DCE procedure appears to be more sensitive than the SCE in detecting polyps and carcinomas when patient preparation has been meticulous (69), but reliability is claimed to be low in less ideal situations (82). Some radiologists believe that the DCE procedure should be used routinely instead of the SCE except in certain contraindicated situations; others believe that it should be a standard second procedure; still others believe that it is indicated when the conventional examination gives unsatisfactory or equivocal results (82). Often, a combined procedure of SCE followed by partial evacuation of the contrast solution and performance of an air study is done, but the barium contrast solution used for the single-contrast procedure is not ideal for a double-contrast procedure (82). Some recent studies of the diagnostic efficiency of the SCE and DCE have shed light on the issue. They are reported later in this section.

Because BE remains the only practical first test for comprehensive investigation of the colon in patients with signs or symptoms suggestive of colonic disease, it is particularly suitable for the high-yield criteria evaluation technique. One such study is described later in this section.

The Diagnostic Efficiency of BE

The ability of various diagnostic procedures to detect the existence of colonic polyps is of great interest because of the presumption that a large proportion of colon cancers originate in polyps (33). About 100,000 new cases of colon cancer are diagnosed each year; if they are detected while localized, 5-year survival rates are high. Otherwise, patients have about a 17-percent 5-year survival rate (47). The detection and subsequent monitoring or removal of polyps is viewed by some as the best available method of cancer control.

Table 12 presents a summary of studies of the sensitivity of BE in detecting colonic polyps. The recent studies of the number of colonic polyps missed on BE but found on subsequent colon-

oscopy have two important findings. First, the double-contrast examination appears to be much more sensitive than the standard examination in detecting polyps, especially small lesions. Second, as polyp size increases, the sensitivity of the double-contrast examination approaches that of colonoscopy. Though the studies from which these conclusions were drawn suffer from serious design flaws, these findings are too pervasive and strong to be discounted.

What do these findings imply for the use of BE in the detection of polyps? Unfortunately, the information is incomplete. We do not know how the DCE and SCE compare on specificity. If the DCE examination were to yield a very high proportion of false-positive results, thereby necessitating more expensive followup, its apparent superiority to the SCE would need to be explored further. Nevertheless, at this time, in patient groups for which the detection of polyps is the goal, the double-contrast examination appears to offer greater diagnostic efficiency.

These studies can also be interpreted as measuring the additional contribution of colonoscopy to the detection of polyps. Does a colonoscopy following a BE make a significant contribution to polyp detection? BE sensitivity results presented in table 12 indicate that colonoscopy offers large proportional improvements in sensitivity only for small polyps. Current evidence suggests that polyps less than 1 cm in size have a 1- to 2-percent incidence of cancer (3). Thus, only 1 or 2 in 1,000 of the small polyps missed by BE could be expected to be cancerous. This additional yield of extra cancers would have to be considered against the high cost of colonoscopy.

Several important limitations of the design are common to all of the studies summarized in the table. * First, each was subject to serious patient selection biases. Patients with negative BEs whose physicians saw no reason to refer to colonoscopy were excluded from every study. In one study, the only patients selected were those

*The studies also have been criticized on the ground that the colonoscopists had access to BE findings before performing their own examinations (3, 72). Because the studies were not intended to compare colonoscopy and BE as direct substitutes for another, this criticism is of no concern here.

Table 12.—The Sensitivity of Barium Enema in the Detection of Polyps

Study*	Year(s) of data collection	Patient sample	Study design	Definition of sensitivity	Reported sensitivity
Thoeni and Menuck (116)	1974-76	210 patients undergoing colonoscopy subsequent to barium enema (BE)	Colonoscopists had results of BE at hand BE technique not standardized Both DCE and SCE performed	Proportion of confirmed polyps detected by test Polyps were confirmed by one or both examinations If seen on BE and not found on colonoscopy, repeat BE confirmed	DCE 88.0% SCE 54.8%
Laufer, et al (71)		46 patients undergoing colonoscopy as followup to positive DCE	Colonoscopists had results of DCE at hand DCES were performed at single Institution with standard technique.	Proportion of confirmed polyps detected by X-ray Confirmed polyps defined as Identified on both DCE and colonoscopy, or on subsequent endoscopy or subsequent DCE examination	DCE 94%
Liencke, et al (72)	1971-74	64 patients undergoing colonoscopy subsequent to BE	Colonoscopists had results of BE at hand BE technique not standardized, not performed at single Institution Results were not reported according to type of BE examination performed Patients who had technically unsuccessful colonoscopies were excluded from study	Proportion of confirmed polyps detected by BE Colonoscope commonly used to arbitrate presence or absence of polyps, except when multiple X-rays, colonoscopic examinations or surgical examinations available	< 5mm In size BE 44.0% 5mm-1cm In size BE 44.0% 1-2cm In size BE 77.4% 2 or more cm In size BE 93%
Williams, et al (122)	1974	182 patients referred for colonoscopy because of positive BE or unexplained bleeding with a normal BE	Colonoscopists had results of BE at hand BE technique not standardized • about 50% performed at same Institution with DCE the rest were referred from other hospitals, most were SCE	Proportion of confirmed polyps detected by BE A polyp was confirmed if found on colonoscopy If reported on BE and not on colonoscopy, was assumed to be false positive due to poor preparation	< 5mm In size DCE 73.0% SCE 13% 5mm- 1cm In size DCE 87% SCE 40% 1cm-2cm in size DCE 99% SCE 75% > 2cm in size DCE 95% SCE 79% BE 80%
Wolff, et al (124)		500 patients referred for endoscopy after one or more BEs	Colonoscopists had results of BE at hand. Referrals for confirmation of abnormality classification	Proportion of polyps confirmed by colonoscopy found on BE	BE 80%

*Numbers in Parentheses refer to references in the list that appears at the end of this background Paper

with positive DCE examinations, The net effect is that the sensitivity of the X-ray examination is overestimated, because some lesions were undoubtedly missed in the group that was not referred. The extent of the overestimation is unknown, but the problem is more troublesome for small polyps.

In all but one study, the BE technique was not standardized. The X-rays were performed in different hospitals or facilities from the place of the colonoscopy. Patient preparation was not controlled or even monitored. While this lack of control makes it difficult to judge the quality of radiologic method, it may also mean that the findings are more representative of the diag-

nostic efficiency typical of a community center rather than of performance at an outstanding center.

These limitations do not negate the central implications of this literature: If a patient is suspected or at risk of colonic polyps or cancer, and if X-ray studies are planned, the best approach is a DCE followed by colonoscopy only if the X-ray examination is positive or suggests the need for further workup. * Though formal analyses of the costs of the single-and double-contrast procedures and of colonoscopy were not conducted, this result is based on implicit assess-

*This conclusion must be tempered by recognition of the differences in competence in the conduct of DCE.

ment of the cost of the three procedures in relation to their diagnostic efficiency. Notice, however, that the findings do not reveal the conditions under which the benefit from either kind of X-ray study of the colon is worth its costs. What patient signs, symptoms, or risk factors are likely to correlate highly with the existence of polyps, particularly large polyps or carcinomas of the colon? What are the ultimate benefits and costs of offering the double-contrast examination to these or other kinds of patients? These questions have not been addressed in the literature.

A recent study of the diagnostic efficiency of DCE in rectal cancer illustrates the limitations of diagnostic efficiency as the evaluative endpoint. The rectum has long been considered the province of the rigid sigmoidoscope, a relatively inexpensive and widely available diagnostic instrument. (In 1980, California's medicaid program paid \$13.17 for a proctoscopy compared to \$39 for a DCE.) SCE has never been particularly suitable for visualization of the rectum. With increasing acceptance of the double-contrast technique, however, the ability of X-rays to detect lesions in the rectum has increased markedly. Evers and her colleagues reviewed the records of 66 cases of cancer of the rectum in two institutions which routinely use the double-contrast method (3.5). In 66 of those cases, both proctoscopy and DCE were performed, although which came first and whether the results of the earlier procedure were available to those who performed the later procedure were not known. The observed true-positive rate of the DCE was 91 percent, while that of proctoscopy was 86 percent. Should patients presenting with symptoms suggestive of rectal carcinoma (constipation and bleeding) be examined by DCE instead of, or in addition to, the proctoscope? The results of the study are insufficient to answer this question, although the authors concluded that "the rectum is the province of the radiologist" (35). The specificity of the two examinations, the number of true-positive cases that would be found and the stage at which they are detected, the ultimate effect on survival, and the cost of the examinations and subsequent medical care would have to be known to fully understand the

implications of an affirmative or negative response to the question.

High-Yield Criteria for BE

Gerson and colleagues have recently reported on an attempt to apply a high-yield criteria method to SCE (49). The study was intended to identify symptoms, signs, and laboratory findings which could be used as criteria for referral to SCE. Physicians referring patients to a university-affiliated radiology department for SCES over a 22-month period in 1974 and 1975 were required to fill out a requisition form containing information on over 40 specific patient attributes—signs, symptoms, and laboratory findings. The presence or absence of these findings was correlated with the outcome of the BE examination. An attribute was included in the high-yield criteria set if its likelihood ratio, L_i , was significantly greater than 1. L_i was defined as follows:

$$L_i = \frac{\text{proportion of abnormal BEs with attribute } i}{\text{proportion of normal BEs with attribute } i}$$

When all attributes with values of L significantly greater than 1 were identified, the "high-yield" set was considered complete. Only five findings were so identified: rectal mass, fever, abdominal mass, low hematocrit, and positive stool benzidine (a test for blood in the stool). Had these criteria been used in the sample of patients studied, 36 percent of the BEs would have been avoided, but 22 percent of diseased patients and 10 percent of those with cancer would have been missed. Thus, the high-yield criteria so selected did not perform well, especially since an even greater deterioration in performance could be expected in other patient samples.

Although these results are disappointing, they do not provide definitive evidence against the use of high-yield criteria; performance may have been improved by using other methods or statistical approaches. If performance were to remain low after reanalysis, however, this would suggest that the symptoms suggestive of colonic disease are also suggestive of other problems, and that colonic disease occurs in too broad an

array of symptom complexes to provide criteria that will perform well.

This study also highlights a potential danger inherent in implementing a high-yield criteria referral process for a test with such a wide referral base (unlike skull X-rays, where the potential population is limited to those with head injury). Suppose, for example, that the five findings had performed well and that they were accepted as referral criteria for barium enemas. The presence of fever would be one such criterion. Does this imply that all persons or even all persons over 40 presenting with fever should be referred? Surely not, but the mere existence of the referral list would be likely to provoke referral of more pa-

tients with marginal clinical indications, or isolated findings, with a consequent further deterioration of diagnostic yield. MacEwan has demonstrated that the physician's strong suspicions (probability > 0.50) of carcinoma of the colon is related to a high proportion of positive cases (77). The Gerson study did not include such subjective criteria in its initial attribute list, but they are probably surrogates for the existence of patterns of multiple-objective findings that are likely to occur together in the presence of disease. It would be worth exploring how combinations of symptoms contribute to the separation of normal from abnormal X-rays.