

A Stool Collection Device: The First Step in Occult Blood Testing

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Despite widespread fecal blood testing, the technique of gathering stool for sampling has remained uncontrolled. We sought to describe how patients have contended with this awkward step, to study artifact caused by toilet water, and to construct a collection device that prevents sampling problems. A survey of 250 patients showed that most (56%) had retrieved stools from the toilet basin, 17% used a pan or other household receptacle, 10% used newspaper or tissue paper, and 17% had been unable or unwilling. Sampling stool from the toilet basin introduces error because 4% to 75% of blood leaches from the fecal surface into surrounding water after only 4 to 12 minutes, and many toilet sanitizers cause false-positive guaiac reactions. We describe an inexpensive, disposable stool collector; outpatient compliance has been 97% using this device. To avoid biochemical artifact and facilitate stool sampling, we advocate that a collection device be incorporated into the occult blood testing process.

[MeSH terms: guaiac; occult blood; patient compliance. Other indexing terms: fecal blood testing; HemoQuant; stool collection; stool collection device]

THE AMERICAN Cancer Society currently recommends annual surveillance for colorectal neoplasia by fecal blood testing in persons aged 50 or older. However, the testing process remains unsystematized. The many tests available differ in biochemical and clinical performance (1-5). Numerous dietary constituents (6-8), medications (5, 9-12), storage of assay materials (13), delays in specimen handling (5, 14), and fecal hydration (5, 15, 16) alter the reactivity of commonly used tests. Proper interpretation of fecal blood test results mandates careful control of each step of the testing process.

The first step in the screening process, procurement of stool for testing, has been largely ignored in commercial test kit instructions and in many reported screening trials (17-27). Patients are usually directed to smear an aliquot of stool onto a test pad using a 3-inch wooden stick provided in the kit—an unwieldy task for some, especially if the stool has sunk. How the stool is gathered and sampled has surprisingly been left to patients' ingenuity. Sampling a stool from within the toilet basin may not only be technically difficult, but create potential measurement artifact due to disintegration of the specimen, loss of blood from stools into the surrounding water, or contamination from commercial disinfectants and other toilet water additives. Regardless of which assay is used,

variability in the technique of stool collection may confound results.

This report presents the range of approaches patients have taken to recover their stools for sampling; examines potential quantitative and qualitative measurement errors caused by sampling stools from toilet bowl water; and describes a device designed to prevent collection-related problems in fecal occult blood testing.

Materials and Methods

A brief questionnaire was distributed to adult Mayo Clinic outpatients to explore the range of approaches patients have used to collect stools for occult blood testing. To encourage candid responses neither patient identification nor demographic information was requested. About 80% of patients returned the questionnaire. Patients were asked to detail how they had contended with previous stool collections for occult blood testing. Because a stool collection device has been used at the Mayo Clinic for more than 2 years, only questionnaires from patients who had had occult blood testing outside of the institution were used; thus questionnaires from 250 respondents were consecutively evaluated. The questionnaire was reviewed and approved by our Institutional Review Board.

The HemoQuant assay (Minneapolis Medical Research Foundation, Minneapolis, Minnesota) was used to quantify the extent of hemoglobin transfer from stools to toilet water (28). Stools from healthy volunteers were thoroughly blended with blood and different amounts of water to produce test specimens with variable consistency and moderately elevated hemoglobin concentrations (range, 2.1 to 6.4 g/L). Corresponding to the superficial layer of stool, which is the portion most likely to be sampled by patients, thin specimen slabs of 3 × 10 × 10 mm or 6 × 10 × 10 mm were prepared. Slabs were placed on a fiber glass mesh and immersed in a beaker of tap water without agitation. After time intervals of 4 to 12 minutes, fecal slabs were removed, and separate assay of the slabs and of their water baths were done. Results are reported as percent of initial fecal hemoglobin lost from the assayed stool or recovered from the water bath. Aliquots of all fecal specimens were weighed before and after desiccation to determine their percent dry weight.

The effects of several time-release toilet bowl sanitizers on guaiac pad test reactivity were evaluated. Several commonly used brands were selected that are placed into the holding tanks and advertised to last from 1 to 4 months. Four brands generated chlorine (Tank 'n Bowl, Twin Oak Products, Plano, Illinois; 2000 Flushes, Kleenco, Jersey City, New Jersey; Depend-O Crystal Clear, Boyle-Midway, New York, New York; and Bully, French Household Products, Rochester, New York) and two did not (Vanish Drop-ins, Drackett Products, Cincinnati, Ohio; and Bloo, Kiwi Brands, Douglassville, Pennsylvania). Dispensers were placed in 2-liter tanks of tap water. At 30 minutes and at 5 hours tanks were gently stirred and sampled. Solutions were placed as a single drop on each window of the guaiac pad tests Hemocult (Smith-Kline Diagnostics, Sunnyvale, California) and Seracult (Propper Manufacturing, Long

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Table 1. Effect of Time-Release Toilet Bowl Sanitizers on Guaiac Pad Test Reactivity*

Toilet Bowl Sanitizer	Incubation Time of Dispenser in 2-Litre Water Tank	
	Hemoccult/Seracult	Hemoccult/Seracult
	30 minutes	5 hours
Chlorine-generating brands		
Tank'n Bowl	++/++	+++ / +++
2000	++/++	+++ / +++
Flushes	++/++	+++ / +++
Depend-O		
Crystal		
Clear	++/++	+++ / +++
Bully	++/++	+++ / +++
Nonchlorine-generating brands		
Vanish		
Drop-inst†	(-/-)	(-/-)
Bloo†	(-/-)	(-/-)

* A single drop of each test solution was added to guaiac pad windows.

† Although they do not cause a positive guaiac reaction, these products contain a blue dye that colors the tank water and stains the guaiac test pad windows blue.

Island City, New York) and tested immediately with addition of the developer.

The purpose of a collection device for occult blood testing is to conveniently, inoffensively, and reliably mobilize the stool for patient sampling before it mixes with toilet water. Because stool blood testing is advocated for a large segment of the general population, such a device must be cheap, easy to mail, use, dispose of, and mass produce. The collection device we describe was developed to satisfy these criteria.

Results

Patient approaches to stool collection varied, but could be grouped into four general categories. Most (56%) sampled their stools from within the toilet bowl water after retrieving the specimens using various techniques, including the short wooden stick provided in the test kit, long-handled ladle, rubber glove, or bare hand with rolled-up sleeve. Some (17%) caught their stool in a make-shift receptacle, such as a kitchen pan, bowl, or coffee can. Others (10%) defecated onto newspaper, toilet tissue, or wax paper held in the hand or placed on the floor. Finally, several patients (17%) indicated that they had been unwilling or unable to collect their stool. One patient specified that the stools could not be sampled because after several attempts they were lost through the exit port at the bottom of the toilet basin.

Loss of hemoglobin from the prepared fecal slabs into water baths varied greatly, ranging from 4% to 75% of initial concentrations. Leaching of blood into the surrounding water bath progressed over time from all fecal slabs (Figure 1). Loss of hemoglobin was greater from thinner slabs and from slabs of softer consistency. Nearly half the blood from some softer stools had transferred into the water bath after 8 minutes.

Water solutions sampled from the four tanks holding chlorine-generating toilet bowl sanitizers all tested positive with both Hemoccult and Seracult (Table 1). Reactions were moderately positive from solutions sampled 30 minutes after sanitizer placement and strongly positive

from solutions sampled after 5 hours. Neither of the non-chlorine-generating sanitizers reacted with the guaiac pads; however, both brands (Vanish Drop-ins and Bloo) contained a blue dye that colored the water and stained the test pad windows a mildly to moderately deep sky blue (Table 1).

The collection device (Ability Building Center, Inc., Rochester, Minnesota) consists of two components: a cardboard yoke support that is water-repellent on the dorsal surface and a flushable filter paper dish that is porous to fluid (Figure 2). The paper dish attaches to the support on four tabs punched out of the cardboard itself. As the device is lightweight and flat before its use, it can be carried inconspicuously or mailed in an envelope. To prepare the support for mounting, patients fold up the pleated side wings that serve to stabilize the yoke and set the dish at the appropriate distance beneath the toilet seat. The collection device is then taped onto the back half of the toilet seat (Figure 2). Finally, the center of the paper dish is depressed to shape a bowl that will accommodate defecation. Once the stool is evacuated onto the dish, an unadulterated sample may be obtained and sent to the physician, hospital, or laboratory.

To dispose of the stool, the patient simply lifts the paper dish at each tab site and flushes both the dish and the stool. The cardboard support is detached and either discarded into a wastebasket or saved for additional samplings. If more than one stool test is requested, extra paper dishes and sampling tubes or test pads are given to the patient to use with the same cardboard support.

This stool collection device has been used routinely for nearly 2 years with HemoQuant testing of outpatient, inpatient, and mail-in samples at the Mayo Clinic. More than 100 000 tests have been done after the device has been used, and no major technical problems have been

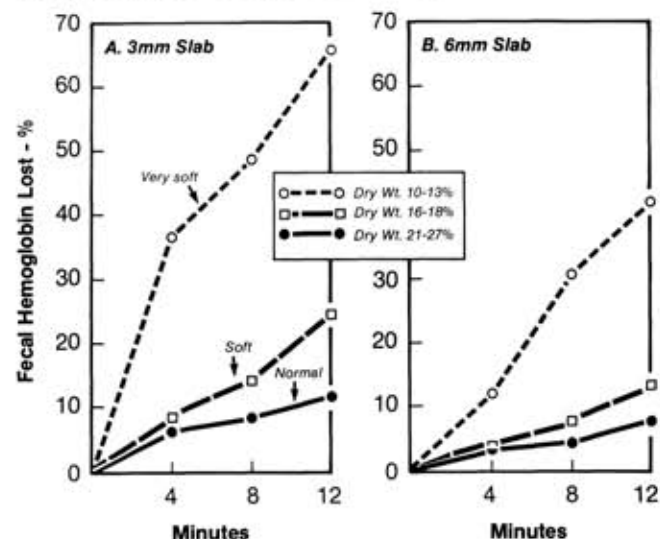


Figure 1. Effect of stool consistency, thickness, and incubation time on blood loss from stool into water bath. Fecal slabs of variable consistency measuring $3 \times 10 \times 10$ mm (A) or $6 \times 10 \times 10$ mm (B) were placed in a nonagitated tap water bath for variable times. Loss of fecal hemoglobin was determined by the HemoQuant assay and expressed as percent of initial fecal hemoglobin concentration. Each point represents the average of two to five fecal preparations.

reported to date. Sample return rates have been extremely high among this large private patient population; based on a 1-week period of observation, 915 HemoQuant tests were ordered and 887 samples were returned to the laboratory for analysis. This 97% return rate reflects both high patient compliance and technical success in obtaining the stool sample using a system that incorporates the collection device.

Discussion

Despite widespread promotion of fecal blood screening, there has been conspicuous patient reticence on the matter of stool collection. Failure to control this critical step in the screening process results in inescapable biochemical artifact, an awkward task for patients, and possibly reduced compliance. To avoid these undesirable sequelae, we have developed an inexpensive stool collector that is easy to mail, use, discard, and mass produce and that has been successfully used in outpatient, inpatient, and mail-in settings.

We were unable to find published data on patients' approaches to stool collection for occult blood testing. Recent recommendations on how to do fecal blood tests include no mention of techniques to mobilize the stool for sampling (29). Responses from the survey in this report document the resourceful extremes taken by patients to accomplish this unpleasant task, including defecating onto a newspaper placed on the floor, catching the stool in a frying pan, and manually retrieving the stool from the bottom of the toilet basin. However, most techniques involved sampling the specimen from within the toilet bowl water.

Sampling the stool from the toilet basin introduces major variability. The portion of fecal blood lost into the toilet water is unpredictable. Using HemoQuant, we found that nearly half the blood contained in the superficial 3-mm layer of some stools leaches into the surrounding water after only 8 minutes, whereas other stools more avidly retain blood. As fecal blood levels from patients with colorectal cancer are commonly in the lower elevated range (15, 16, 30-32), this degree of measurement distortion might easily lead to false-negative results and missed diagnoses.

There are additional toilet water variables that may obscure guaiac pad test results. Common household disinfectants added to toilet holding tanks cause chemical false-positive reactions. False-positives may also occur if stools are sampled from toilet bowl water contaminated by blood from urine or menstruation (33). Other substances excreted in urine, such as ascorbic acid (9) and naturally occurring constituents (11), may inhibit the reaction with guaiac or related leuco-dyes used for blood detection and cause false-negative results. Finally, variable fecal hydration may alter the reactivity of guaiac pads (5, 15, 16).

Studies analyzing compliance to stool testing (1, 24, 26, 34-37) have shown the influence of certain demographic and socioeconomic factors but have not elaborated on patient aversion to the ordeal of stool collection. One report has shown that personal objection to stool

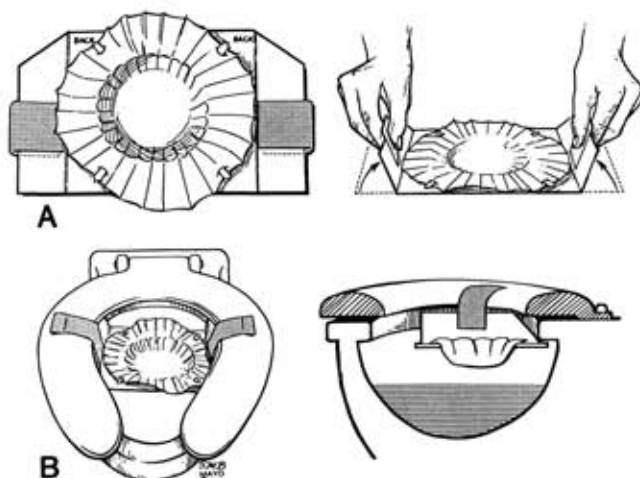


Figure 2. Collection device for stool sampling. The device consists of two components: a cardboard yoke and a flushable, easily detachable paper dish. Side-wings are folded up along pleat lines to stabilize the yoke and to fix the paper dish at the appropriate distance beneath the toilet seat (A). Attachment position of stool collection device. For serial stool testing, the yoke may be re-used with additional paper dishes before disposal (B).

sampling was more common in nonvolunteers than in volunteers to a Hemoccult screening program (38). Patient compliance has ranged from 19% to 85% in reported screening trials, generally being higher after a physician visit (17-27, 34-36). Compliance to guaiac pad testing has been as low as 26% (39) and 30% (24) even in patients who have registered to participate in screening. Patient reluctance to labor through the unpleasant retrieval of stool may influence these low compliance rates. The present study does not specifically test the impact of the stool collector on patient compliance. However, in our somewhat unique outpatient practice at the Mayo Clinic, the return rate of fecal specimens for the HemoQuant test, which incorporates the collecting device, was 97%.

To avoid biochemical error and to facilitate a cumbersome and unpleasant chore, we advocate the use of a collection device as a prelude to stool sampling in the occult blood testing process.

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References

1. SIMON JB. Occult blood screening for colorectal carcinoma: critical review. *Gastroenterology*. 1985;88:820-37.
2. AHLQUIST DA, BEART RS. Use of fecal occult blood tests in the detection of colorectal neoplasia. *Probl Gen Surg*. 1985;2:200-10.
3. WINAWER SJ, FLEISCHER M. Sensitivity and specificity of the fecal occult blood test for colorectal neoplasia. *Gastroenterology*. 1982;82:986-91.
4. OSTROW JD, MULVANEY CA, HANSELL JR, RHODES RS. Sensitivity and reproducibility of chemical tests for fecal occult blood with an emphasis on false-positive reactions. *Am J Dig Dis*. 1973;18:930-40.
5. AHLQUIST DA, MCGILL DB, SCHWARTZ S, TAYLOR WF, ELLEFSON M, OWEN RA. HemoQuant, a new quantitative assay for fecal hemoglo-

- bin: comparison with Hemoccult. *Ann Intern Med.* 1984;101:297-302.
6. ILLINGWORTH DG. Influence of diet on occult blood tests. *Gut.* 1965;6:595-8.
7. MACRAE FA, ST. JOHN DJ, CALIGIORE P, TAYLOR LS, LEGGE JW. Optimal dietary conditions for hemoccult testing. *Gastroenterology.* 1982;82:899-903.
8. SCHWARTZ S, ELLEFSON M. Quantitative fecal recovery of ingested hemoglobin-heme in blood: comparisons by HemoQuant assay with ingested meat and fish. *Gastroenterology.* 1985;89:19-26.
9. JAFFE RM, KASTEN B, YOUNG DS, MACLOWRY JD. False-negative stool occult blood tests caused by ingestion of ascorbic acid (vitamin C). *Ann Intern Med.* 1975;83:824-6.
10. LIFTON LJ, KREISER J. False-positive stool occult blood tests caused by iron preparations: a controlled study and review of literature. *Gastroenterology.* 1982;83:860-3.
11. AHLQUIST DA, SCHWARTZ S. Use of leuco-dyes in the quantitative colorimetric microdetermination of hemoglobin and other heme compounds. *Clin Chem.* 1975;21:362-9.
12. FLEMING JF, AHLQUIST DA, MCGILL DB, ZINSMEISTER AR, ELLEFSON RD, SCHWARTZ S. Influence of aspirin and ethanol on fecal blood levels as determined by using the HemoQuant assay. *Mayo Clin Proc.* 1987;62:159-63.
13. MARKMAN HD. Errors in the guaiac test for occult blood. *JAMA.* 1967;202:846-7.
14. STROEHLEIN JR, FAIRBANKS VF, GO VL, TAYLOR WF, THOMPSON JH JR. Hemoccult stool tests: false-negative results due to storage of specimens. *Mayo Clin Proc.* 1976;51:548-52.
15. MACRAE FA, ST. JOHN DJ. Relationship between patterns of bleeding and Hemoccult sensitivity in patients with colorectal cancers or adenomas. *Gastroenterology.* 1982;82:891-8.
16. AHLQUIST DA, MCGILL DB, SCHWARTZ S, TAYLOR WF, OWEN RA. Fecal blood levels in health and disease: a study using HemoQuant. *N Engl J Med.* 1985;312:1422-8.
17. GILBERTSEN VA, MCHUGH R, SCHUMAN L, WILLIAMS SE. The earlier detection of colorectal cancers: a preliminary report of the results of the Occult Blood Study. *Cancer.* 1980;45:2899-901.
18. GREGOR DH. Occult blood testing for detection of asymptomatic colon cancer. *Cancer.* 1971;28:131-4.
19. HASTINGS JB. Mass screening for colorectal cancer. *Am J Surg.* 1974;127:228-33.
20. GLOBER GA, PESKOE SM. Outpatient screening for gastrointestinal lesions using guaiac-impregnated slides. *Am J Dig Dis.* 1974;19:399-403.
21. BRALOW SP, KOPEL J. Hemoccult screening for colorectal cancer: an impact study on Sarasota, Florida. *J Fla Med Assoc.* 1979;66:915-9.
22. MILLER SF, KNIGHT AR. The early detection of colorectal cancer. *Cancer.* 1977;40:945-9.
23. ROZEN P, FIREMAN Z, TERDIMAN R, HELLERSTEIN SM, RATTAN J, GILAT T. Selective screening for colorectal tumors in the Tel-Aviv area: relevance of epidemiology and family history. *Cancer.* 1981;47:827-31.
24. SONTAG SJ, DURCZAK A, ARANHA GV, CHEFFEC G, FREDRICK W, GREENLEE HB. Fecal occult blood screening for colorectal cancer in a Veterans Administration Hospital. *Am J Surg.* 1983;145:898-94.
25. GNAUCK R. Dickdarmkarzinom-screening mit Haemoccult. *Leber Magen Darm.* 1977;7:32-5.
26. HARDCASTLE JD, FARRANDS PA, BALFOUR TW, CHAMBERLAIN J, AMAR SS, SHELDON MG. Controlled trial of faecal occult blood testing in the detection of colorectal cancer. *Lancet.* 1983;2:1-4.
27. WINAWER SJ, ANDREWS M, FLEHINGER B, SHERLOCK P, SHOTTENFELD D, MILLER DG. Controlled trial of fecal occult blood testing for the detection of colorectal neoplasia. *Cancer.* 1980;45:2959-64.
28. SCHWARTZ S, DAHL J, ELLEFSON M, AHLQUIST DA. The "Hemo-Quant" test: a specific and quantitative determination of heme (hemoglobin) in feces and other materials. *Clin Chem.* 1983;29:2061-7.
29. GNAUCK R, MACRAE FA, FLEISHER M. How to perform the fecal occult blood test. *CA.* 1984;34:134-47.
30. DORAN J, HARDCASTLE JD. Bleeding patterns in colorectal cancer: the effect of aspirin and the implications for faecal occult blood testing. *Br J Surg.* 1982;69:711-3.
31. DYBDAHL JH, DAAE LN, LARSEN S, MYREN J. Occult faecal blood loss determined by a ⁵¹-Cr method and chemical tests in patients referred for colonoscopy. *Scand J Gastroenterology.* 1984;19:245-54.
32. AHLQUIST DA, FLEMING JF, MCGILL DB, MOERTEL CG, SCHWARTZ S, WEIAND HS, RUBIN J. Longitudinal patterns of occult bleeding in colorectal cancer. *Gastroenterology.* 1987;92:1290.
33. DARDICK KR. Hematuria and false-positive tests for stool occult blood. *Am Family Physician.* 1984;29:201-2.
34. NICHOLS S, KOCH E, LALLEMAND RC, HEALD RJ, IZZARD L, MACHIN D, MULLEE MA. Randomised trial of compliance with screening for colorectal cancer. *Br Med J. [Clin Res.]* 1986;293:107-10.
35. MORROW GR, WAY J, HOAGLAND AC, COOPER R. Patient compliance with self-directed Hemoccult testing. *Prev Med.* 1982;11:512-20.
36. ELWOOD TW, ERICKSON A, LIBERMAN S. Comparative education approaches to screening for colorectal cancer. *Am J Public Health.* 1978;68:135-8.
37. SNYDER HALPER M, WINAWER S, BRODY RS, ANDREWS M, ROTH D, BURTON G. Issues of patient compliance. In: SHOTTENFELD D, SHERLOCK P, WINAWER SJ, eds. *Colorectal Cancer: Prevention, Epidemiology, and Screening.* New York: Raven Press;1980:299-310.
38. SPECTOR MH, APPLIGATE WB, OLMSTEAD SJ, DiVASTO PV, SKIPPER B. Assessment of attitudes toward mass screening for colorectal cancer and polyps. *Prev Med.* 1981;10:105-9.
39. WINCHESTER DP, SHULL JH, SCANLON EF, et al. A mass screening program for colorectal cancer using chemical testing for occult blood in the stool. *Cancer.* 1980;45:2955-8.