SPECIAL

Errors in Delivery of Cancer Genetics Services: Implications for Practice

KARINA L. BRIERLEY, MS, CGC, DANIELLE CAMPFIELD, MS, CGC, WHITNEY DUCAINE, MS, CGC, LINDSAY DOHANY, MS, CGC, TALIA DONENBERG, MS, CGC, KRISTEN SHANNON, MS, CGC, ROBIN C. SCHWARTZ, MS, CGC, ELLEN T. MATLOFF, MS, CGC

ABSTRACT—Advances in genetics have prompted recommendations that all healthcare providers perform genetic counseling and testing. Some experts are concerned about potential negative outcomes from cancer genetic testing performed without genetic counseling by certified genetics professionals. We report a national series of cases illustrating negative outcomes of cancer genetic testing performed without counseling by a qualified provider. Three major patterns emerged from analysis of these cases: 1) Wrong genetic test ordered, 2) Genetic test results misinterpreted, and 3) Inadequate genetic counseling. Negative outcomes included unnecessary prophylactic surgeries, unnecessary testing, psychosocial distress, and false reassurance resulting in inappropriate medical management. *Conclusion:* With the complexities of cancer genetic counseling and testing, it may be unrealistic to expect all clinicians to provide these services. A more realistic approach is better provider education and a framework in which healthcare providers identify patients who would benefit from a referral to a certified genetic counselor or experienced cancer genetics professional.

KARINA L. BRIERLEY, MS, CGC, Certified Genetic Counselor, Cancer Genetic Counseling, Yale Cancer Center, Yale University School of Medicine, New Haven; DANIELLE CAMPFIELD, MS, CGC, Certified Genetic Counselor, Cancer Genetic Counseling, Yale Cancer Center, Yale University School of Medicine, New Haven; WHITNEY DUCAINE, MS, CGC, Certified Genetic Counselor, Beaumont Cancer Genetics Program, Rose Cancer Center, Royal Oak, MI; LINDSAY DOHANY, MS, CGC, Certified Genetic Counselor, Beaumont Cancer Genetics Program, Rose Cancer Center, Royal Oak, MI; TALIA DONENBERG, MS, CGC, Certified Genetic Counselor, University of Miami School of Medicine, Jackson Health System, Miami, FL; KRISTEN SHANNON, MS, CGC, Certified Genetic Counselor, Program Manager, Center for Cancer Risk Assessment, Senior Genetic Counselor, MGH Cancer Center, Boston, MA; ROBIN C. SCHWARTZ, MS, CGC, Assistant Professor in Genetics and Developmental Biology and Pediatrics, Certified Genetic Counselor, University of Connecticut Health Center, Neag Comprehensive Cancer Center, UCONN Health Partners, West Hartford; ELLEN T. MATLOFF, MS, CGC, Research Scientist, Department of Genetics, Director, Cancer Genetic Counseling, Certified Genetic Counselor, Yale Cancer Center New Haven. *Corresponding author:* ELLEN T. MATLOFF, MS, Research Scientist, Department of Genetics, Director, Cancer Genetic Counseling, Certified Genetic Counselor, Yale Cancer Center, 55 Church Street, Suite 402, New Haven, CT 06510; (203) 764-8400; fax (203) 764-8401; email: ellen.matloff@yale.edu.

Introduction

CANCER genetic counseling and testing have become an integral part of clinical management over the past decade and are critical in tailoring cancer surveillance, chemoprevention and risk reduction in patients at increased risk. Over the past three decades, genetic counseling has been provided by a variety of health care providers with specialized genetics training, including genetic counselors, MD and PhD geneticists, and nurses with specialized training in genetics. The discovery of BRCA1 and BRCA2, along with the sequencing of the human genome, spurred recommendations that all healthcare providers perform their own genetic counseling and testing. Healthcare providers are likely facing increasing pressure to order cancer genetic testing due to advertising from cancer genetic testing companies and increased media attention. The public perception is that genetic testing is simple and that the result is either positive or negative and therefore easy to interpret. The reality is that there are dozens of genetic tests for cancer predisposition, with many more on the horizon. The results can include positive, uninformative negative, true negative, and variants of uncertain significance. Subsequent recommendations for the patient

and the entire family hinge on the correct interpretation. The interpretation will become more complex as more tests become available and as we begin to understand the impact of modifying genes on the penetrance of cancer gene mutations.

The potential benefits of having non-genetics providers do their own genetic counseling and testing has been discussed elsewhere[1]; however, many experts are concerned about the potential for negative outcomes from cancer genetic testing performed outside of the setting of pre-test and post-test genetic counseling by a certified genetics professional.[2] These concerns are based on data showing that many clinicians lack the necessary genetics knowledge and skills to provide adequate genetic counseling,[2–5] that direct-to-consumer (DTC) advertisements may be the primary source of information for these providers,[3] that these advertisements are often misleading, incomplete, or inaccurate,[3,6] and that federal oversight of genetic tests and advertisements for genetic tests is lacking.[3,6] Cases illustrating the risks and negative outcomes in the field have not yet been published in a series. We sought to explore a series of cases in the United States in which pre-test counseling by a certified genetics professional was not performed.

Case Descriptions and Themes

In the spring of 2009 we invited genetic counselors who participate in the National Society of Genetic Counselors (NSGC) Cancer Special Interest Group (Cancer SIG) listserv to submit cases of adverse outcomes of cancer genetic counseling and testing performed by non-genetics providers for inclusion in a case series report. A patient who learned of our compilation through a mutual colleague also contacted us directly to independently submit her personal story for consideration. We report 21 cases which illustrate unique themes chosen for discussion.

Three major patterns emerged from analysis of these cases.

1. Wrong genetic test ordered.

In many cases the wrong genetic test was ordered by the provider (Figs. 1–3). The most common scenario was a provider ordering BRCA1 and BRCA2 testing when MSH2, MLH1 and MSH6 testing (the genes involved with Lynch syndrome / Hereditary Non-Polyposis Colorectal Cancer (HNPCC)) was indicated (Figs. 1,3). However, it was also common for: a) full sequencing of a gene(s) to be ordered when testing for a familial muta-

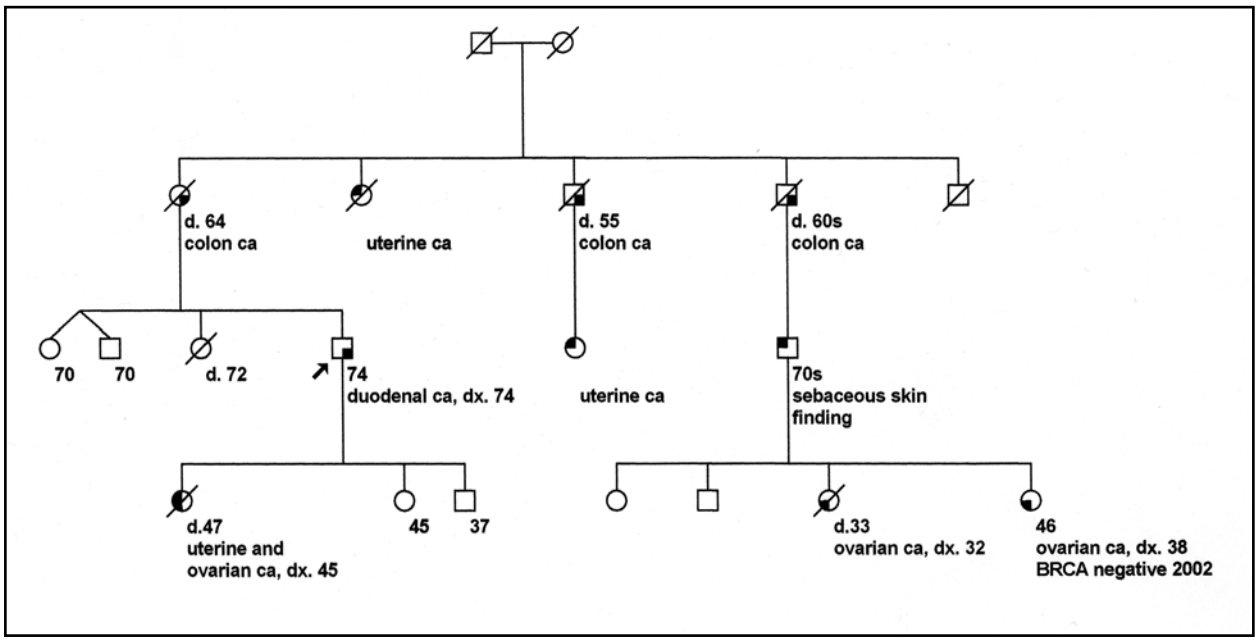

Figure 1.—A 32-year-old woman was diagnosed with invasive epithelial ovarian cancer and died of her disease at age 33. Her younger sister was then diagnosed with early-stage invasive epithelial ovarian cancer (endometrioid adenocarcinoma) two years later and the family oncologist offered her BRCA testing in 2002 that was negative. The family was not referred for genetic counseling and was informed that the cancers in their family were not hereditary.
In 2004, a second cousin was diagnosed with synchronous ovarian (undifferentiated carcinoma, endometrioid type) and uterine (endometrioid type with squamous differentiation) primaries at age 45 and was treated by the same oncologist. She died at age 47 in 2006. In 2009, her father was diagnosed with a duodenal cancer at age 74 and was referred to genetic counseling by his surgeon. A detailed family history was elicited which revealed a distant, but strong, family history of colorectal and uterine cancers. The patient was offered MSH2 and MLH1 sequencing and was found to carry a mutation in MSH2. The living cousin who has survived her early-onset ovarian cancer was counseled and tested and carries the same mutation. If the correct testing had been ordered in 2002, it is possible that the clinical outcome for the relative who died of advanced ovarian and uterine cancers at age 47 may have been altered.

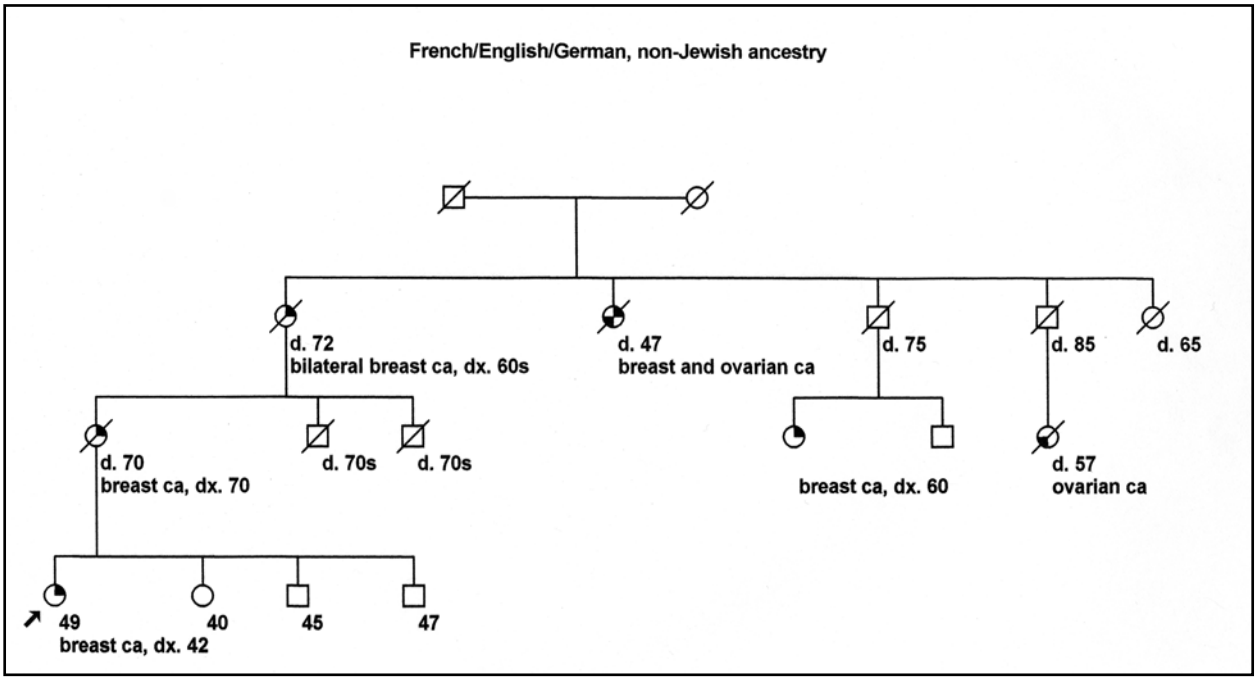

Figure 2—A 49-year old breast cancer survivor was referred for genetic counseling and testing by her oncologist because she had developed breast cancer at age 42. The patient met with a genetic counselor and understood the implications of testing BRCA+ and indicated that she would elect to have a prophylactic bilateral mastectomy and oophorectomy if she carried a mutation.
The patient's insurance, however, required her to be seen at another facility for testing where she was seen by a nurse who had been trained by the laboratory with the patent for BRCA1 and BRCA2 testing. The patient was offered testing at this facility, tested BRCA negative, and a copy of her test results were sent to her in the mail. The patient was relieved for herself and her family members, and continued regular breast surveillance.
Four months later the patient faxed her oncologist and genetic counselor a copy of her test results. Her genetic counselor noticed that she had been tested for the three common Jewish BRCA mutations; however, this patient was not of Jewish ancestry. The wrong test had been ordered. Full sequencing of BRCA1 and BRCA2 was then ordered and the patient tested positive for a BRCA2 mutation.
The patient went on to have a prophylactic bilateral mastectomy and total abdominal hysterectomy and her family members learned that they were in fact at risk for this familial BRCA2 mutation. If this error in testing had not been detected, the potential implications for this patient and her entire family are clear.

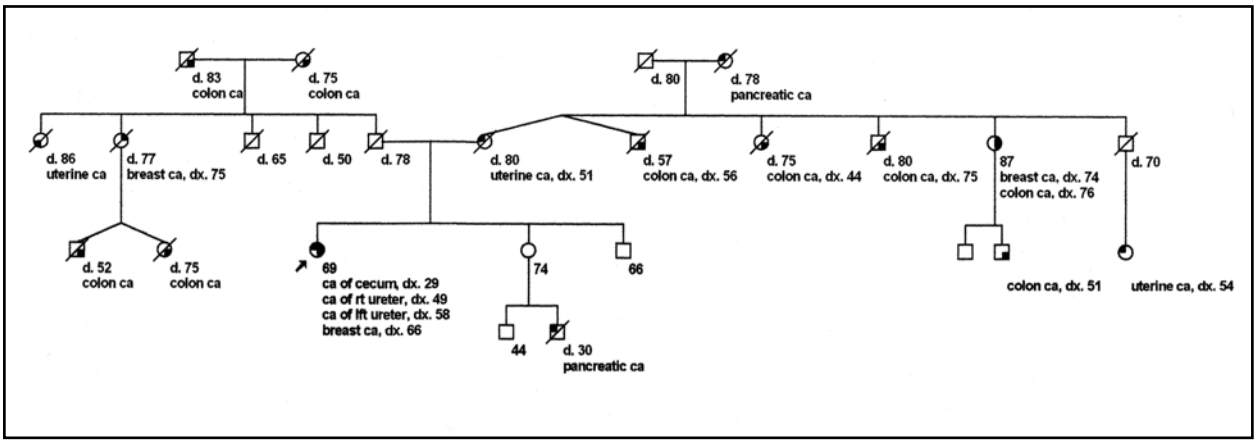

Figure 3.—A 69-year old woman was referred for genetic counseling by her new oncologist based on her personal and family history of cancer. She was diagnosed with cancer of the cecum at age 29, the right ureter at age 49, the left ureter at age 58, and of the right breast at age 66. Her previous oncologist had ordered BRCA ($3120),[7] and APC and MYH ($1920)[7] testing and no mutations were detected. She was then informed that she did not have a hereditary cancer syndrome.
This patient has a strong family history of colon, endometrial and pancreatic cancer. Her genetic counselor ordered MSH2, MLH1 and MSH6 testing ($2950)[7] and she was found to carry a mutation in MSH2. This patient underwent $5040 in unnecessary genetic testing, received an incorrect result interpretation, and was given inaccurate results for her family. After the correct testing was ordered and a mutation detected, her affected and unaffected family members were offered the appropriate testing, surveillance and risk reduction options.

tion was indicated, b) full sequencing to be ordered when testing for the common Jewish BRCA mutations was indicated, or c) testing for the common Jewish BRCA mutations to be ordered when full sequencing was indicated (Fig. 2).

Testing scenarios a and b above result in thousands of additional health care dollars being charged to the insurance company and/or the patient. For example, full sequencing of the BRCA1 and BRCA2 genes ($3,340)[7] when testing for a familial mutation ($475)[7] or for the common Jewish BRCA mutations ($575)[7] is indicated results in an additional expenditure of $2,865 or $2,765 per case, respectively. Full sequencing of a gene when testing for a familial mutation was indicated was also seen with testing for other genes in this cohort. In one large medullary thyroid cancer family with a RET mutation, seven family members were tested via full sequencing ($736)[8] when testing for the familial mutation ($420)[8] was indicated. In this one kindred alone, ordering the wrong test resulted in extra health care expenditures of ~$1900.

In some cases, testing for the wrong gene may lead to unnecessary healthcare expenditures and/or potentially missing a deleterious mutation and giving inappropriate medical management recommendations to the patient and family members. In a case from the mid-West, BCR-ABL (somatic testing which has prognostic implications for patients diagnosed with chronic myeloid leukemia and acute lymphoblastic leukemia) was ordered when BRCA testing was indicated.

In another, a physician made a referral to the genetic counselor that read, "genetic counseling and BRCA1 and 2 testing." Upon meeting the patient and her brother, the genetic counselor was able to recognize that the brother's mucocutaneous lesions combined with the family history of breast cancer and thyroid disease were indicative of Cowden syndrome. Instead of ordering BRCA testing as directed, the counselor ordered PTEN testing and a deleterious mutation was found.

In a third family with a mild history of several later-onset leukemias, the primary care physician ordered p53 testing. However, on review of the test results, fluorescence in situ hybridization (FISH) testing for p53 and ATM were ordered on a peripheral blood sample (diagnostic testing that is intended to be run on a bone marrow sample). The patient was instructed to have this testing every year, which again would not have identified a germline mutation and thus would not have been appropriate or helpful.

In a recent case, a pediatrician ordered genetic testing for the 'breast cancer gene running in the family' in her 10 and 13 year old female patients—a decision that is controversial, at best[9–11]—and called the genetic counselor to report that both children were positive. The genetic counselor reviewed the results and saw that the testing was actually for the MTHFR gene (a gene involved in folate metabolism and associated with neural tube defects and cardiovascular disease). During their discussion, the pediatrician was surprised to learn that mutations in the MTHFR gene are not related to hereditary breast and ovarian cancer and that testing children for BRCA mutations is not recommended.

The most common error in this series was the ordering of BRCA testing when testing for HNPCC was indicated, or vice versa (Figs. 1,3). In fact, BRCA testing has been mistakenly ordered even in families in which a known MSH2 or MLH1 mutation has already been detected in a family member. In one such family, an MLH1 mutation was identified in a woman diagnosed with ovarian cancer at age 51 who had a strong family history of colon, endometrial, ovarian, stomach and kidney cancer. Her sister was tested by her gynecologist and informed that she was negative. It was later determined that the sister had undergone BRCA testing and had not been tested for the MLH1 mutation found in the family.

2. Genetic test results were misinterpreted.

Genetic test misinterpretation was another common theme in this case series (Fig. 4). The most common scenarios include interpreting variants of unknown significance as deleterious mutations, considering a patient 'true negative' when a mutation has not been identified in the family, or deeming a patient 'true negative' or low risk when the wrong testing has been ordered (Figs. 2–3).

Although the interpretations of many of these results are quite complex, test misinterpretation was also reported in straightforward cases. A 37-year old woman with breast cancer and a minimal family history of breast cancer was offered BRCA genetic testing through her surgeon's office in Connecticut and was notified via telephone by the surgeon's secretary that her results were 'normal'. She requested a hard copy of the results and received them a few days later. The patient read on the result page that she has tested 'positive for a deleterious mutation' in BRCA1. Shocked, she then read the written result interpretation and suspected that she did, in fact, carry a mutation. She contacted a cancer genetic counselor, faxed over her results, and learned that her suspicion was accurate.

A second patient from Massachusetts was seen by her gynecologist in 2007 for a routine visit and mentioned her strong family history of cancer. The gynecologist had the patient watch a video from the laboratory with the patent for BRCA1 and BRCA2 testing and then drew her blood for BRCA testing. When the patient hadn't heard back from her physician four weeks later, she called the office

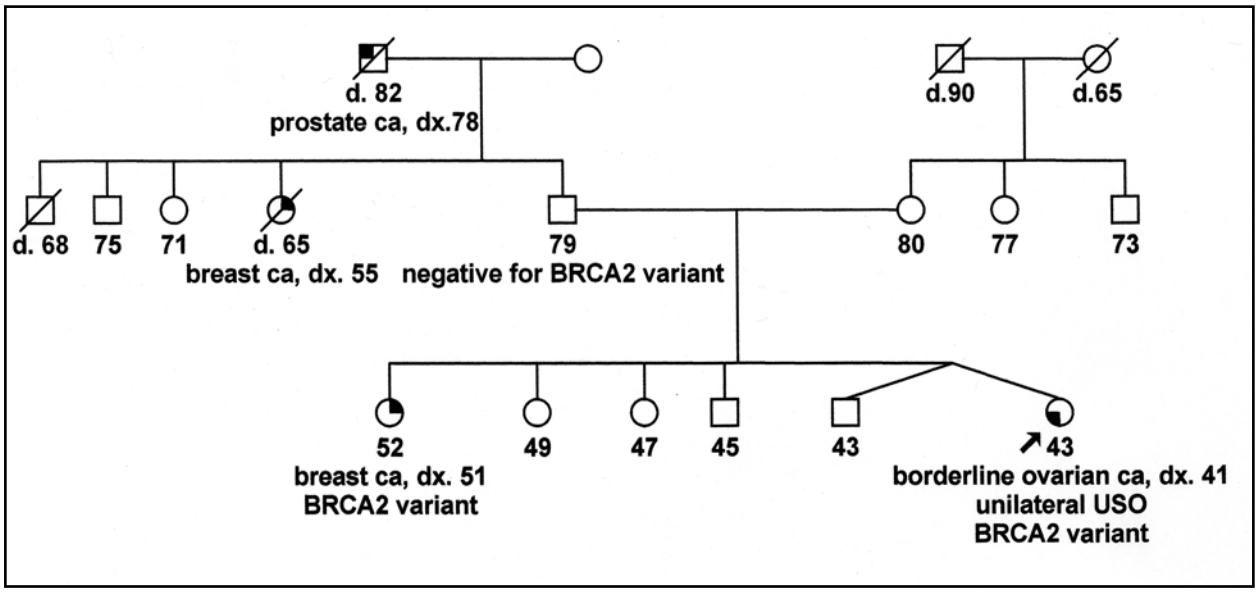

Figure 4.— A 43-year-old woman was offered genetic testing by her oncologist because she had been diagnosed with ovarian cancer at age 41, her sister with breast cancer at 51, and a paternal aunt with breast cancer at age 55. The patient was found to carry a BRCA2 variant of uncertain significance and her sister was tested and found to carry the same. The oncologist counseled both sisters that they were at increased risk for both breast and ovarian cancer, and advised the ovarian cancer survivor to opt for a prophylactic bilateral mastectomy and her sister to have a prophylactic total hysterectomy. The ovarian cancer survivor was then seen by a genetic counselor to confirm this recommendation. Her pathology reports were reviewed and her tumor was a borderline ovarian cancer, which is rarely seen in the context of a BRCA mutation. The patient's father was offered testing for the variant and he did not carry the variant seen in his daughters; therefore, the breast cancer on that side of the family was not caused by this variant. Based on this information, the daughters did not opt for prophylactic surgery.

and her physician reported that the results were normal and her risks were now those of the general population (inaccurate, even with negative results). Almost two years later the patient's sister, seen by the same gynecologist, also had testing through this office and tested positive for a BRCA mutation. Eight months later the original patient decided to obtain a copy of her own test results for her permanent file. When she read her result she learned that she carried the same BRCA mutation. Her physician apologized for the error and simply said the result was misread. This patient had a prophylactic bilateral salpingo-oophorectomy immediately and a prophylactic bilateral mastectomy in December 2009; luckily, her pathology was negative.

Another patient who was diagnosed with breast cancer at age 33 and had a significant paternal family history of ovarian, prostate, and early-onset breast cancer had genetic testing through her oncologist's office. Her strong personal and family history was highly suggestive of a BRCA mutation, and she qualified for full sequencing and additional testing that looks for large deletions and rearrangements in BRCA1 and BRCA2 (BART analysis) based on the laboratory's criteria at the time. Her initial sequencing came back negative, and her oncologist contacted her by phone to tell her that her cancer was not hereditary. A few weeks later the oncologist received her BART analysis results in the mail, showing that the patient did, indeed, carry a BRCA1 mutation. The oncologist called the genetic counselor, confused about why the patient who tested negative had now been found to carry a mutation. Even if a mutation had not been found by rearrangement testing in this patient, the interpretation that this cancer "was not hereditary" was inaccurate. In that case, the patient should have been considered "uninformative," the cancers in her family would still be considered hereditary and she would have been offered surveillance and risk reduction options similar to that of BRCA carriers.

In another case, a 24-year old woman who had been diagnosed with breast cancer at age 23 was offered genetic testing by her surgeon and was found to carry a variant of uncertain significance. Her surgeon interpreted this variant as a true mutation and counseled the patient to have a bilateral mastectomy, which she did. The case was presented at a case conference several years later and only then was it recognized that the patient did not carry a known deleterious mutation. In a separate case at a different institution, a woman with a family cancer history not entirely consistent with hereditary breast and ovarian cancer syndrome was found to carry a BRCA variant of uncertain significance. The genetic counselor advised her that this variant could not be interpreted at this time. However, the woman's unaffected cousin had testing for the variant through her personal physician

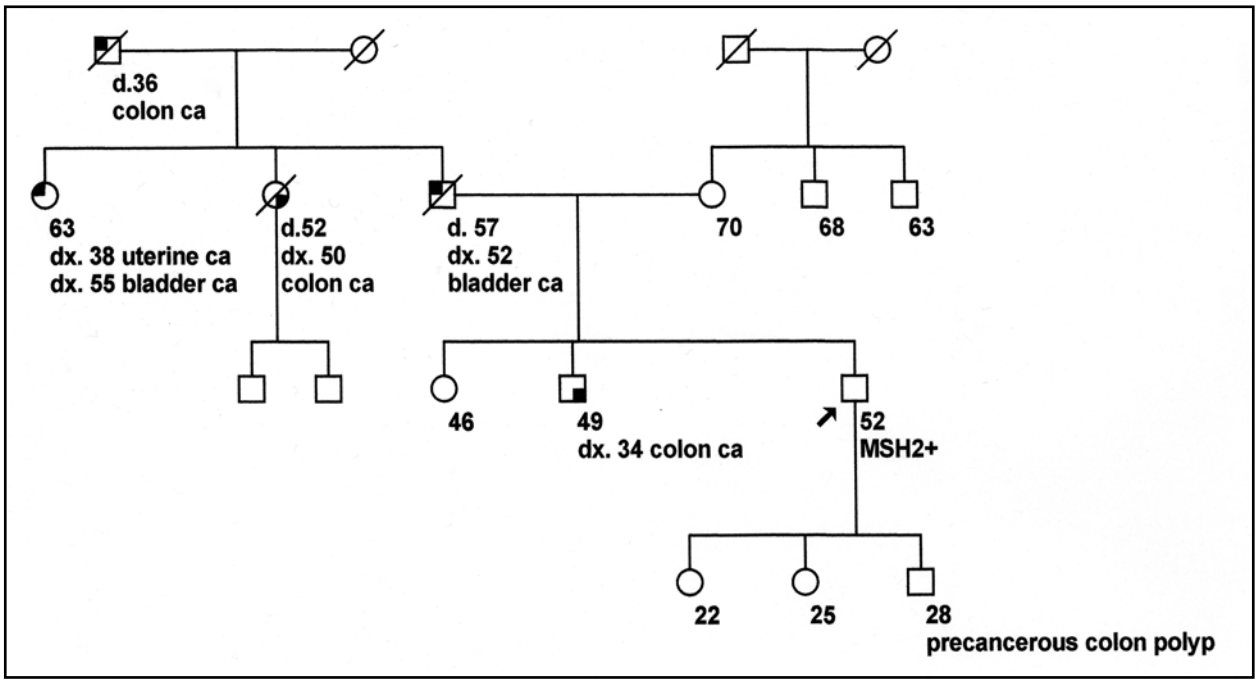

Figure 5.—A 52-year-old man was followed by his gastroenterologist based on his strong family history of colon cancer. The gastroenterologist had tried to convince the patient to have genetic testing for several years, but the patient was anxious and concerned and postponed testing. He presented for a screening colonoscopy and while in the recovery area and still heavily sedated the nurse asked him to sign some forms. The patient was too groggy to sit up, so his wife signed the forms for him. Four weeks later he received an envelope from his doctor's office in the mail with a copy of his MSH2 positive test results. Written on the results was a note from the secretary that read, "Your children need genetic testing when teenagers. You will need a colonoscopy in one year." His children were already ages 22, 25, and 28, and the son had already had a precancerous colon polyp removed during a colonoscopy with the same physician. There was no mention of the associated risks of uterine, ovarian and other cancers seen with MSH2 mutations. There was no recommendation for genetic counseling or follow-up with the ordering physician. The patient became depressed and anxious and states that he regrets having genetic testing.

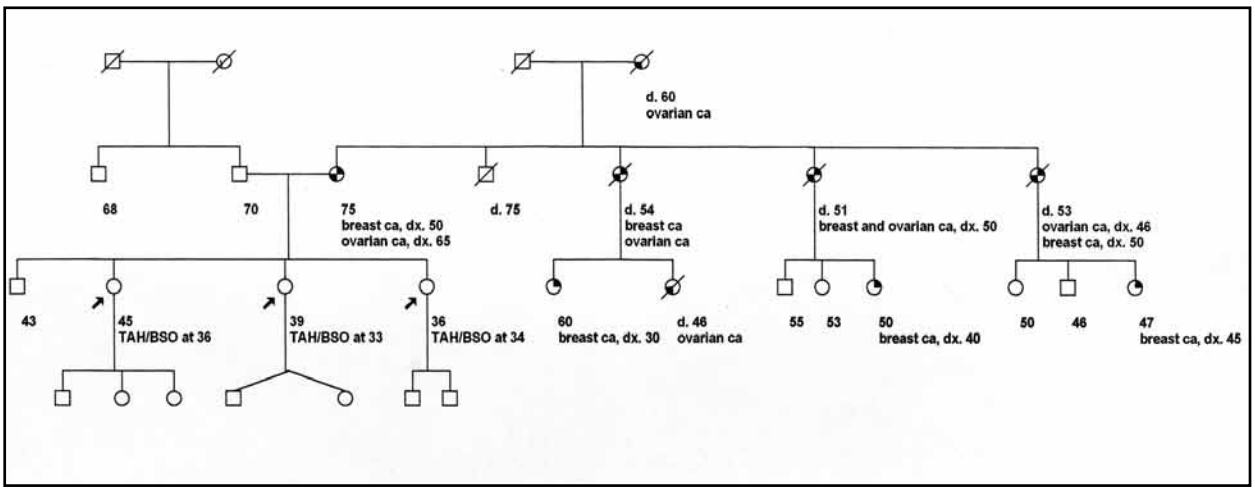

Figure 6.—Three sisters with a strong family history of autosomal dominant early-onset breast and ovarian cancer presented to their gynecologist in 2003 and were told that the cancers in their family were hereditary. The gynecologist counseled them that genetic testing was not necessary because the cancer history was so striking. All three sisters were advised to have prophylactic total hysterectomies and did so at ages 33, 34 and 36. All went through surgical menopause and were advised that they were not candidates for hormone replacement therapy based on their family history of breast cancer. The youngest sister wanted more children and was advised that she must have the surgery immediately based on the family history. The eldest sister presented for a research study on menopausal decision-making for women with a family history of breast cancer, indicating that she and her sisters were considering tamoxifen or prophylactic bilateral mastectomies based on the history. The family history was tagged as hereditary and the patient was referred to a genetic counselor, who suggested that the patient's 75-year-old mother have counseling and testing. The mother was found to carry a BRCA1 mutation, as were several other affected relatives. All three daughters were then tested for the familial mutation and tested true negative.

and was found to carry the same variant. The physician advised this young woman to have a prophylactic bilateral mastectomy, which she did, and the physician is now trying to convince a 25-year-old family member to have her ovaries removed prophylactically based on the fact that she, too, carries this variant. Even in known mutation carriers, prophylactic oophorectomy is almost never recommended in healthy women before the age of 35.

3. Inappropriate, inadequate or lack of genetic counseling

In the third theme identified in this cohort, adequate pre- and/or post-test genetic counseling was not provided (Figs. 5–6) resulting in psychosocial distress (Fig. 5), inappropriate prophylactic surgeries (Fig. 6) and/or inappropriate surveillance and management recommendations for the patient and extended family members (Figs. 1,2,4).

Psychosocial distress is a recurrent theme in this series. A healthy 54-year-old Jewish woman mentioned to her gynecologist during a routine annual visit that her sister had recently been diagnosed with breast cancer at age 50. The physician drew her blood for BRCA testing that day. Several weeks later the patient, a teacher at an elementary school, received a phone call in her classroom from an assistant at her gynecologist's office informing her that she carried a BRCA2 mutation. The patient was with a classroom full of children, had not received pre-test counseling and did not fully understand the information, and described herself as "distraught." She frantically tried to gather information during the school day and met with her physician several days later who informed her that she needed to have a total abdominal hysterectomy and bilateral mastectomies. No options for surveillance or chemoprevention were presented and the patient was overwhelmed, depressed and angry and felt that she was offered no options for support or decision-making. The patient also had two children in their twenties who were at 50% risk and stated that she was not counseled on their risks or how to relay this information to her children.

A healthy 33-year-old woman presented to her annual gynecological visit and reported that she had a family history of ovarian cancer. She was offered a "genetic test for breast cancer" and no other explanation of what the test meant. Several weeks later she returned to her physician's office, was told that "the gene test came back positive," and was handed the business card of a breast surgeon. She believed that she already had breast cancer and needed to see a surgeon to remove this cancer. The patient was eventually offered genetic counseling and stated that she was depressed, angry that she had been offered testing without informed consent, and wished she had never had testing.

A healthy 23-year-old Jewish woman whose mother was recently diagnosed with breast cancer at age 56 (and whose father's family history was negative) was seen by her primary care physician for her annual visit. The daughter reported that her mother was offered genetic counseling and testing and that the results were pending. Instead of waiting for the mother's test results to come back and then referring this young woman for counseling and testing, the physician drew the daughter's blood and sent it for testing. This approach to genetic testing added expense and an extra layer of unnecessary strain on the family who was dealing with the mother's breast cancer diagnosis and were waiting for her genetic test results.

A 37-year-old woman of Italian ancestry recently diagnosed with breast cancer reported no known family history of breast, ovarian or pancreatic cancer. Her oncologist ordered genetic testing as part of her overall work-up and called her on a Friday afternoon to report that she was BRCA2 positive. The patient was so frantic that the oncologist contacted a genetic counselor to see if the patient could be seen on an emergency basis that Friday afternoon, which she was. The patient and her husband were seen for an urgent two-hour consultation and the patient was shocked that she was also at risk for ovarian cancer, and that her children and siblings were at 50% risk to carry this mutation. Three years later, this patient reports that she still regrets having testing and believes she might have made a different decision had she had informed consent before testing.

Discussion

There are many explanations for adverse events or medical errors in cancer genetics as well as other specialties. These factors include inadequate knowledge or training, insufficient experience, poor communication, stress, sleep deprivation, time pressures, multiple distractions, overwork, fatigue, and case complexity.[12–14] Any health care provider, including certified genetic counselors, could make the errors reported in this case series. However, we contend that these errors are likely to be made less frequently by certified genetic counselors or experienced cancer genetics professionals than by nongenetics providers since the literature suggests that inadequate knowledge or experience and unfamiliarity with a task contribute to medical errors.[12]

Certified genetic counselors are more likely to be familiar with genetic test reports and have extensive training and experience in genetics including genetic test result interpretation and providing informed consent and psychosocial support to individuals undergoing genetic testing. In a field with as much growth as cancer genetics and in a subspecialty that includes recommendations for prophylactic removal of healthy tissue for the patient and their entire family, it is critical to strive for accurate result

interpretation, accurate testing recommendations, and adequate informed consent and psychosocial support.

A recent study showed that 91% of physicians were aware of genetic testing for hereditary breast and ovarian cancer, and 60% were aware of testing for hereditary colorectal cancer.[15] Some non-genetics healthcare providers are performing cancer genetic counseling and testing and are likely doing it well. These providers invest the significant time and energy required to do their own genetic counseling and testing. They spend several hours with each patient in order to provide adequate pre- and post-test counseling, offer psychosocial support and resources, refer patients to long-term research studies and clinical trials as needed, follow up to ensure that family members at-risk are notified and counseled, and re-contact patients as new, relevant information emerges. These physicians must also invest the time needed to educate themselves about genetics and to keep themselves current on the rapidly emerging data in this field.

However, the average gynecologist is allotted 21.6 minutes per patient encounter, and the average general practitioner 19.5 minutes.[16] Most physicians lack the time to provide genetic counseling and testing services[2,17], and the vast majority do not have an adequate understanding of the genetics concepts necessary to provide appropriate counseling and testing.[4,5,18] In fact, although most physicians obtain some family history information on their patients, most do not obtain a family history detailed enough to provide accurate genetic risk assessment and interpretation.[17,19]

In addition, most providers do not have the background or time needed to discuss the complex ethical and psychosocial issues involved in genetic testing, such as the impact of results on other family members, confidentiality, and patient autonomy.[2,20] These providers may not be sufficiently aware of current policy guidelines or laws related to genetic testing in order to appropriately counsel their patients on critical issues such as insurance discrimination, insurance coverage for testing and prophylactic surgeries, or testing minors for adult-onset conditions.[19,21,22] Even medical students nearing graduation lack the genetic knowledge necessary for providing their own genetic counseling and testing.[23] The published medical literature almost uniformly reports that providers are not equipped to provide their own genetic counseling.[2,4,5,19] The genetic testing company with the patent on BRCA1 and BRCA2 testing offers free 'training' of health care providers and their office staff so that they can offer their own genetic counseling and testing.[24] However, it is our contention that a few hours of training by the company generating a profit from the sale of these tests does not adequately prepare providers to offer their own genetic counseling and testing services. Unfortunately, these providers sign off on each test request form and are legally responsible for the outcome of such testing.

Of even greater concern, the well-meaning physicians who assume full responsibility for this testing are often delegating many of the genetic testing responsibilities to other staff members. A recent pilot survey of obstetrician-gynecologists in New York revealed that office staff, including secretaries, were responsible for completing genetic test requisitions, reviewing test results, and communicating results to patients.[25] In fact, 86% of respondents indicated that their secretaries reported genetic test results out to patients over the phone. Forty-four percent indicated that their secretaries filled out their genetic testing requisitions and 59% stated that their secretaries review the results.[25] This trend is disturbing and likely presents a huge liability for these ordering physicians, their practices and their institutions.

Both physicians and patients are being pressured by direct to consumer (DTC) advertisements from genetic testing companies.[26] Although there are no data linking DTC marketing and the rise of adverse events seen in the field, it is clear that recent marketing efforts by these laboratories place pressure on health care providers to order genetic tests and take responsibility for interpreting the results.[20] The advertisements do not mention to patients or providers that 'genetic testing should be provided to the public only through the services of an appropriately qualified health care professional, who should be responsible for both ordering and interpreting the test, as well as for pre-test and post-test counseling of individuals and families regarding the medical significance of test results and the need, if any, for follow-up', as has been recommended by the American College of Medical Genetics.[27] Due to concerns about DTC marketing by genetic testing companies and increasing reports of adverse events by members, a patient advocacy group for individuals affected by hereditary breast and ovarian cancer recently urged the Health and Human Services Secretary's Advisory Committee on Genetics, Health, and Society to recommend federal regulation of marketing of genetic tests by laboratories, tracking of adverse events resulting from this marketing, and a requirement that patients be informed about their genetic counseling options prior to testing.[28] This advocacy group argued that these marketing practices discourage referrals to genetics experts and as a result they have seen an increasing number of members who were given misinformation or too little information about their genetic test results and were not informed about the availability of certified genetic counselors in their area.[29]

Several lawsuits based on inadequate genetic counseling have already been settled or tried. In the Estate of

Lees *vs* Durfee the family of Patricia Lee successfully sued her physician for not referring her for genetic counseling and testing, in spite of a documented maternal and paternal family history of early-onset breast and ovarian cancer. Ms. Lee was diagnosed with ovarian cancer and died before the conclusion of the trial which settled in her favor in 2006. In a similar case in Washington, a physician documented his patient's personal and family history of breast cancer and family history of ovarian cancer, but did not counsel the patient on her options for prevention. The patient died of ovarian cancer at age 43 and her family filed a wrongful death suit, arguing that her doctor should have tried to prevent her from developing the hereditary disease in her family. The case was settled in 2001 for 1.6 million dollars. Many cases have also been settled in favor of the plantiff regarding the failure to recognize hereditary colorectal cancer in a family.[30,31]

One argument that is often made in support of non-genetics healthcare providers ordering their own testing is that there are not enough certified genetic counselors to see all of the patients who require these services. Much of the evidence for this shortage is anecdotal and there has been very little focus on obtaining more accurate data about this potential shortage, the reasons for this shortage (including lack of appropriate financial reimbursement mechanisms), and ways of increasing the number of certified genetic counselors.[2,32] In many large, urban areas there are enough qualified professionals to handle the patient-load. In fact, the wait time to see a cancer genetic counselor in these areas is shorter than the wait time for a routine gynecological visit at local offices. In more sparsely populated, underserved areas where access to certified genetic counselors may be a well-founded concern, there are options for accessing genetic counseling by certified providers via satellite clinics and phone- and/or internet-based telemedicine services.[32,33] Several major health insurance companies now cover these off-site counseling services.[34]

The anticipated risks of DTC marketing of cancer genetic tests included misinterpretation of test results and therefore inappropriate medical decision-making for the patient and the entire family.[35] Included under these risks were unnecessary health care expenditures, unneeded prophylactic surgery in women who are not truly at high-risk, or false reassurance and thus, less surveillance in women who are found not to carry a BRCA mutation.[35] Our cohort demonstrates that these concerns are valid.

This study also illustrates the high burden on health care resources when inappropriate genetic testing is ordered or test results are misinterpreted. Health care expenditures in the United States continue to rise rapidly at twice the rate of inflation. Experts agree that this is in part due to inflated prices, inappropriate care and waste.[36] An argument can be made that an investment by hospitals, HMOs and practices to hire a certified cancer genetic counselor to provide risk assessment, genetic counseling and testing would be worthwhile in order to offset the cost of tens of thousands of dollars of waste in unnecessary genetic tests and unnecessary prophylactic surgeries, as illustrated in these cases. These costs do not account for the tremendous emotional, physical and psychological tolls paid by patients and their families who receive inadequate counseling, and surveillance and risk reduction advice, or the physicians who are sued for their well-meaning actions. For all of these reasons, health insurance companies may someday require genetic counseling by a board certified provider before determining coverage for testing.[37]

Far-reaching complexities in the area of genetic testing are expected as the marketplace expands to on-line testing and direct-to-consumer testing including low penetrance genomic testing panels of more limited clinical significance. At least one such company now offers testing for the common Jewish BRCA mutations in their panel and will perform testing on children[38], even though adult-onset disease testing for children has been discouraged in clinical practice guidelines of many medical organizations.[9–11] This site does not discuss the ethical or psychosocial concerns raised by testing minors for adult-onset conditions and, in fact, includes a blog entry from the Director of Research who describes ordering genetic testing on her seven-year old and 12-year old sons.[39] A recent survey of primary care physicians revealed that a significant number of them (31%) would 'unconditionally' recommend testing a healthy 13-year old girl for her mother's BRCA mutation.[21] The ethical, legal, social, financial and psychosocial ramifications of widespread genetic testing without appropriate counseling must be addressed as we move into the era of direct-to-consumer testing.

This small series of patients does not account for the experience of all patients undergoing genetic counseling and testing by their nongeneticist providers, and is a select sample representing poor outcomes in the United States. The method of case collection in this study was qualitative, and not systematic, and the collection of cases from cancer genetic counselors may be an important cause of bias in this sample. Data regarding variables related to the providers and/or healthcare settings that may have contributed to the adverse events in these cases were not systematically collected. Thus, multivariate analysis to determine with certainty which variables are significant contributors to these adverse events is not possible. However, these data may be difficult to collect in a more

systematic way because these adverse events are not routinely reported and may only come to attention when, or if, patients or their family members are later seen by a provider with expertise in cancer genetics.

This small case series does illustrate disturbing trends documented nationwide in the field since providers have been pushed to order their own cancer genetic testing. The available literature supports limited time, inadequate genetics knowledge, and increased demand from DTC marketing as potentially important factors which may limit the feasibility of clinicians providing adequate cancer genetic counseling services. Future studies aimed at determining what percentage of patients tested overall receive inadequate counseling and follow-up as well as studies designed to more accurately assess which healthcare provider and setting variables are associated with these adverse events are needed.

Conclusion

As more and more cancer genetic testing options become available, it will be increasingly important for all healthcare providers to have a basic knowledge of cancer genetics. However, in a complex field characterized by rapid growth in which accurate testing recommendations and result interpretation are critical and when many clinicians are already overburdened, it is unrealistic and unfair to expect all healthcare providers to have the time, knowledge, and training to provide adequate cancer genetic counseling. It may be more realistic to strive for better provider education, better reimbursement for genetic services, and a framework in which healthcare providers are simply expected to identify those patients in their practice who would benefit from a referral to a certified genetic counselor or experienced cancer genetics professional.

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