

# Electronic wound monitoring after ambulatory breast cancer surgery: Improving patient care and satisfaction using a smart phone app

Study results suggest that the demand on health care resources resulting from hospital readmissions and emergency department visits can be reduced with the use of a virtual care platform.

## ABSTRACT

**Background:** Ambulatory surgery for breast cancer is commonplace, but complications can lead to unscheduled care, including readmission to hospital and visits to the emergency department or walk-in clinic. A study was proposed to determine if unscheduled care could be prevented with the use of a secure smart phone application that allows patient and surgeon to communicate and share images of the wound postoperatively.

**Methods:** Clinical details and outcomes were compared for two groups of surgeries: 37 breast operations where patients received conventional follow-up vs 35 breast operations where patients received electronic wound monitoring (e-monitoring) in addition to conventional follow-up. Patients in the e-monitoring group photographed their wounds on post-op days 1, 3, 7, and 14 and sent the images to the surgeon via a smart phone app. The e-monitoring patients were also asked to complete a satisfaction survey online.

**Results:** Significantly more surgeries in the conventional follow-up control

group than the e-monitoring group (22% vs 3%,  $P < .05$ ) required readmission to hospital, an unscheduled visit to the emergency department or walk-in clinic, or both. Most of the e-monitoring patients (83%) used the smart phone app to ask questions and have their concerns addressed. In 10 cases in the e-monitoring group (29% of 35 surgeries), unscheduled care was avoided by reassuring patients or providing early treatment of surgical site infections. Almost all e-monitoring patients felt that electronic wound monitoring improved their care (95%) and would recommend such monitoring to a friend or colleague (90%). All trusted the virtual care platform to keep their personal information private and secure.

**Conclusions:** The study found that electronic wound monitoring was associated with less unscheduled care, a high degree of patient satisfaction, and a likely reduction in cost to the health care system. These promising results justify further research with a prospective randomized controlled trial.

## Background

Ambulatory surgery for breast cancer has become commonplace, with most patients being discharged on the day of surgery.<sup>1,2</sup> Compared with inpatient surgery, outpatient surgery has proved to be more cost-effective<sup>3,4</sup> and to increase patient satisfaction.<sup>3,5,6</sup> This change has been facilitated by a move toward more breast conserving surgery<sup>7</sup> and better postoperative pain control.<sup>8</sup>

Complications of breast surgery still occur, however, and include surgical site infection, hematoma, seroma, and bleeding, which can all lead to unscheduled visits to the emergency department (ED) or walk-in clinic and readmission to hospital.<sup>3,5,6</sup> Readmission rates for ambulatory breast surgery are reported to be as high as 7%.<sup>3,5,6</sup>

Fortunately, evolving technology has provided new ways for patients and surgeons to communicate, and many have been willing to use the tools now available.<sup>9</sup> In the past, patient-

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Dr Hwang is a general surgeon at Vernon Jubilee Hospital and a clinical assistant professor in the Faculty of Medicine at the University of British Columbia.

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surgeon encounters were restricted to either a hospital or a surgeon’s office. Now smart phone applications can allow patients to participate in a videoconference or send secure messages and images to their surgeons, who in turn can respond immediately or at their convenience.<sup>9</sup> App-based technology has been employed to monitor pressure ulcers,<sup>10</sup> diabetic foot ulcers,<sup>11</sup> chronic venous ulcers,<sup>12</sup> and postoperative surgical sites in breast and orthopedic patients.<sup>13</sup> Data collection was completed recently for a randomized trial at Women’s Hospital in Toronto that compared home monitoring by app with conventional follow-up in breast reconstruction.<sup>14</sup>

Based on the premise that electronic wound monitoring (e-monitoring) fills both a clinical and a temporal gap between the day of outpatient surgery and the follow-up office visit 3 weeks later, a study was proposed

to compare conventional follow-up with additional e-monitoring of breast cancer outpatients by smart phone app. The study aimed to determine if unscheduled visits for care and hospital readmission could be prevented by e-monitoring and to assess patient satisfaction with the use of e-monitoring technology for this.

**Methods**

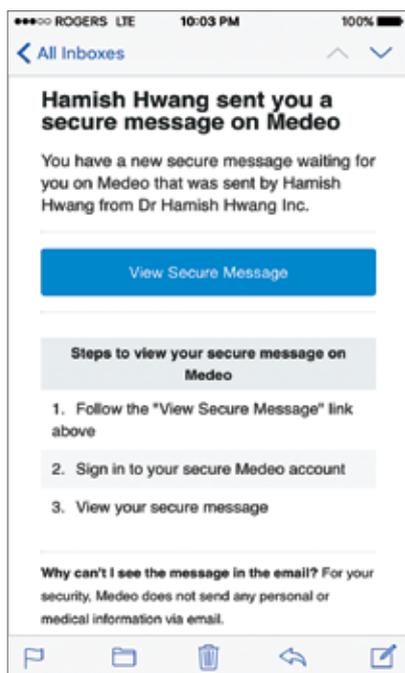
All breast cancer patients in the care of a single surgeon over a 1-year period (February 2015 to January 2016) were prospectively enrolled in an electronic wound monitoring study. The outcomes of 35 surgeries in this e-monitoring group of patients were compared with the outcomes of 37 surgeries in a control group of patients who received conventional follow-up the previous year (February 2014 to January 2015).

February 2015 was chosen as the

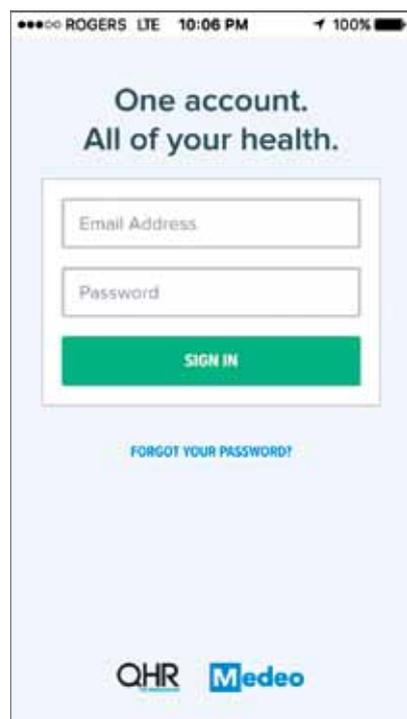
data collection start date for the e-monitoring group because that is when the technology became available.

Only cases where patients were discharged on the same day or the day following surgery were included in the study.

In the conventional follow-up group, care consisted of referral to the ambulatory wound clinic if the patient had a Jackson-Pratt drain and an office visit with the surgeon around 3 weeks post-op. In the e-monitoring group, patients were invited to participate in additional follow-up using Medeo (Figure 1), a virtual care platform that consists of a smart phone app and secure password-protected online account (Figure 2). Patients in the e-monitoring group were asked to take a photo of their wounds post-operatively on days 1, 3, 7, and 14 (Figure 3), and to attach the photos to



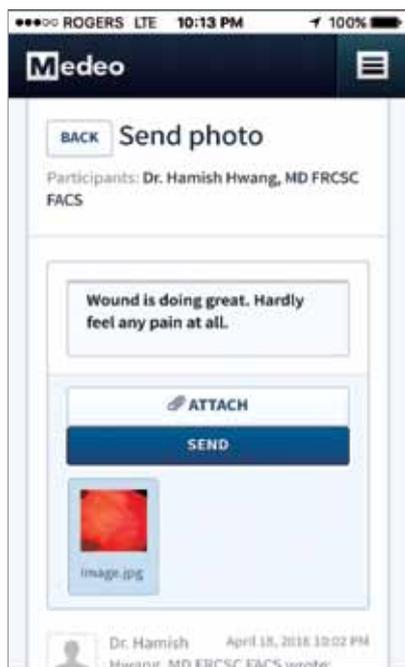
**Figure 1.** Patient receives e-mail invitation from surgeon to communicate using smart phone app and Medeo virtual care platform.



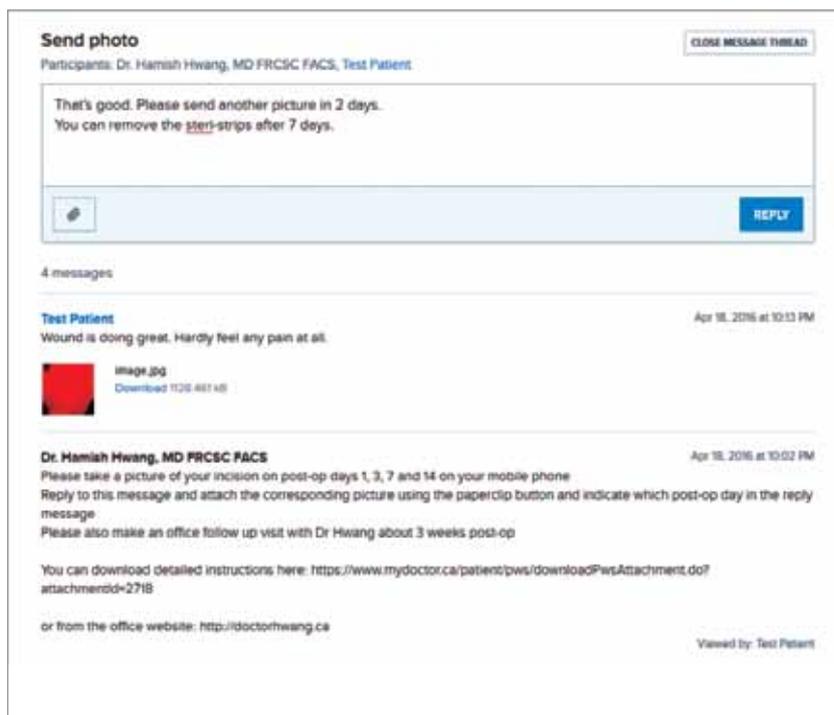
**Figure 2.** Patient logs in to secure Medeo account.



**Figure 3.** Patient receives instructions from surgeon.



**Figure 4.** Patient takes photo of wound with smart phone and then sends message and photo to surgeon.



**Figure 5.** Surgeon receives message on secure site, views photo, and replies to patient.

electronic messages and send them to the surgeon using the smart phone app (Figure 4). The patients were encouraged to ask questions and raise any concerns. The surgeon then responded to each patient message within 24 hours (Figure 5). Patients who successfully attached and sent a wound photo to the surgeon were considered to have made meaningful use of the smart phone app.

Data on patient demographics, breast cancer pathology, operative times, complications, and unscheduled care were recorded in a Microsoft Excel 2010 spreadsheet. Responses to a patient satisfaction survey completed online were analyzed. The chi-square test, student 2-tailed *t* test, and Wilcoxon signed rank test were used on an Internet-based statistical calculator.<sup>15</sup> A probability value of less than .05 was considered significant.

## Results

The mean age of patients in the conventional follow-up group was 65.5 years (range 49 to 90), and the mean age in the e-monitoring group was 60.1 years (range 38 to 78) ( $P < .05$ ).

In the conventional follow-up group, 34 women with an average ASA score of 2.2 underwent 37 surgeries (3 patients required 2 operations each). In the e-monitoring group, 28 patients (27 women and 1 man) with an average ASA score of 2.0 underwent 35 surgeries (7 patients required 2 operations each).

The pathology, tumor characteristics, and hormone receptor status of the breast cancers in each group of patients are summarized in Table 1. While seven cases of ductal carcinoma in situ (DCIS) were seen in the e-monitoring group and none in the conventional monitoring group, the breast cancers were otherwise similar.

The clinical details and outcomes

of the surgeries are summarized in Table 2. While four bilateral mastectomies were performed in the conventional follow-up group and none in the e-monitoring group, the number and kind of procedures were otherwise similar.

Operative time for the conventional follow-up group was 65.0 (SD 31.0) minutes and for the e-monitoring group was 51.4 (SD 15.5) minutes ( $P < .05$ ). The majority of patients in both groups were discharged on the day of surgery. Same-day discharge was 94% in the e-monitoring group and 78% in the conventional follow-up group ( $P = ns$ ). The indications for next-day discharge were bilateral mastectomy in 3 patients, age older than 75 in 4 patients, personal request in 1 patient, recent acute coronary syndrome in 1 patient, and post-op bleed requiring hematoma evacuation in 1 patient with a 20-cm phylloides tumor with extensive varices surrounding the tumor.

Significantly more patients in the conventional follow-up group (22% versus 3% in the e-monitoring group,  $P < .05$ ) were readmitted to hospital, had an unscheduled visit to the emergency department or a walk-in clinic, or both. Of the five patients in the conventional follow-up group who had unscheduled visits to the ED, three presented twice and one presented four times. The two conventional follow-up patients who had unscheduled visits to a walk-in clinic each presented twice. The single patient in the e-monitoring group who presented to the ED with pneumonia on day 3 after surgery did not use the smart phone app.

There was meaningful use of the app in 30 of the 35 e-monitoring surgeries (86%). Three patients either did not own a smart phone or did not have an e-mail address. Two patients were unable to use the smart phone app.

A total of 29 patients (83%) used the smart phone app to ask questions and the same number used the app to communicate about a concern that was then addressed by the surgeon. Fourteen patients raised multiple concerns. Five patients asked for reassurance about minor hematomas or skin blisters that subsequently resolved. Five cases of early wound infection and one case of skin edge necrosis were detected using the app and treated without the need for an extra visit. In two cases, extra electronic visits were scheduled after the office visit to address patient concerns about the wound. In one case, an extra scheduled office visit was arranged. In a total of 10 cases (29% of 35 surgeries), an unscheduled visit to the ED or walk-in clinic was made unnecessary by reassuring patients or providing early treatment of surgical site infections.

Of the 28 patients in the e-monitoring group who were invited

**Table 1. Pathology of breast cancers for conventional follow-up group and electronic wound monitoring group.**

	Conventional follow-up patients n/37 (%)	Electronic wound monitoring patients n/35 (%)
<b>Primary pathology</b>		
Invasive ductal carcinoma	32/37 (86)	25/35 (71)
Invasive lobular carcinoma	2/37 (5)	2/35 (6)
Ductal carcinoma in situ	0/37 (0)*	7/35 (20)
Mucinous carcinoma	3/37 (8)	0/35 (0)
Mixed ductal and lobular carcinoma	0/37 (0)	1/35 (3)
Borderline phylloides tumor	0/37 (0)	1/35 (3)
Multifocal disease	2/37 (5)	4/35 (11)
Lymphovascular invasion	6/34 (18)	4/27 (15)
<b>Tumor characteristics</b>		
Tumor stage	1.53 (mean for 34 cancers)	1.37 (mean for 28 cancers)
Tumor grade (excluding DCIS)	2.06 (mean for 34 cancers)	1.64 (mean for 25 cancers)
<b>Hormone receptor status</b>		
ER positive	30/34 (88)	24/27 (89)
HER-2 positive	6/34 (18)	2/27 (7)

\*  $P < .05$

**Table 2. Clinical details and outcomes for surgeries with conventional follow-up and surgeries with electronic wound monitoring.**

	Conventional follow-up surgeries n/37 (%)	Electronic wound monitoring surgeries n/35 (%)
<b>Procedure</b>		
Bilateral mastectomy	4/37 (11)*	0/35 (0)
Total mastectomy	25/37 (68)	20/35 (57)
Partial mastectomy	8/37 (22)	12/35 (34)
Sentinel lymph node biopsy	24/37 (65)	22/35 (63)
Axillary dissection	7/37 (19)	5/35 (14)
<b>Complication</b>		
Pressure sore	1/37 (3)	0/35 (0)
Bradycardia	1/37 (3)	0/35 (0)
Severe neuralgia	1/37 (3)	0/35 (0)
Leaking drain	1/37 (3)	0/35 (0)
Wound infection	2/37 (5)	6/35 (17)
Minor hematoma	0/37 (0)	2/35 (6)
Skin edge necrosis	0/37 (0)	1/35 (3)
Hemorrhage requiring evacuation	0/37 (0)	1/35 (3)
Pneumonia	0/37 (0)	1/35 (3)
<b>Unscheduled care</b>		
30-day readmission	2/37 (5)	1/35 (3)
Emergency department visit	5/37 (14)	1/35 (3)
Walk-in clinic visit	2/37 (5)	0/35 (0)
30-day readmission, unscheduled emergency department visit, or both†	8/37 (22)*	1/35 (3)

\*  $P < .05$

† One patient had both an unscheduled visit to the ED and readmission to hospital within 30 days.

to complete an anonymous online survey, 20 patients (71%) did so. Responses indicated that 90% did not have difficulty using the app and would recommend e-monitoring to a friend or colleague, while 95% found the app convenient to use and felt it was better for patient care when compared with standard post-op follow-up. All patients trusted the virtual care platform to keep their personal information private and secure.

A sample of responses to an open-ended survey question gives a sense of overall patient satisfaction:

“Response time excellent and with this monitoring service I was able to have antibiotics without going to see my doctor.”

“I found it amazing, very comforting to know my wounds were fine and not have to worry about whether they were okay or not.”

“It took a number of tries to get into the system to start, and then a while to figure out how to upload the pictures, but after that it was easy to use. Very reassuring to know that things were progressing as expected. Perhaps more online assistance would help get things off to a better start.”

“It was nice to hear on days 1 and 3 that everything looked good. Definitely made me feel better and less anxious about how I was healing. Response time was surprisingly fast.”

## Conclusions

New app-based technology<sup>9,16</sup> is being accepted more widely by both patients and physicians and can help with all three objectives of the Institute for Healthcare Improvement’s triple aim<sup>17</sup> initiative:

- Improving the patient experience of care (including quality and satisfaction).
- Improving the health of populations.
- Reducing the per capita cost of health care.

In this study, survey responses indicate clearly that use of a smart phone app improved the patient experience of care. Communicating with the surgeon electronically eased patients’ anxieties and lessened their inclination to visit the emergency department. In 10 cases (29% of 35 surgeries) the surgeon provided reassurance or early diagnosis and treatment of wound infections that might have required visits to the ED at a later date. The e-monitoring patients had significantly fewer hospital readmissions and unscheduled visits to the ED or walk-in clinic than the conventional follow-up patients. The only patient in the electronic wound monitoring group to have an unscheduled visit to the ED did not use the smart phone app. Importantly, 100% of patients felt their confidential information was private and secure.

On a population health basis, the use of smart phone apps and similar technology can also lead to improvements. If unnecessary visits to the ED can be eliminated this not only improves the health of postoperative patients but also of other patients who can receive treatment more promptly in the emergency department because of reduced demand on ED resources.

Unscheduled care places a demand on physicians, hospital personnel, diagnostic services, and other health care resources. In this study, 22% of surgeries in the conventional follow-up group required unscheduled care compared with 3% in the electronic monitoring group. Considering only patients who made meaningful use of the smart phone app, there were no instances of unscheduled care in the e-monitoring group. Electronic follow-up is not only cost-effective by itself when compared with in-person follow-up,<sup>18</sup> it also prevents unscheduled visits to the ED and readmis-

sions, further reducing the per capita cost of health care.

## Challenges

Technical difficulties or lack of familiarity with technology challenged a minority of study subjects and prevented five patients from participating in a meaningful way. Arguably, the patients who need support the most—the elderly and the financially insecure—are also more likely to face barriers to using technology. The five subjects in the e-monitoring group who did not participate included the two oldest patients, aged 75 and 78, and three others aged 49, 51, and 69. Identifying ways to remove barriers to meaningful use of new technology for these vulnerable patients needs to be prioritized, perhaps with a publicly funded smart phone loan program and one-on-one instruction sessions.

The fact that post-op days 1, 3, 7, and 14 did not always fall during the surgeon’s work week presented an unexpected challenge to providing prompt responses to patients. Although the ease of access to technology means a surgeon can be out of town or even out of the country and still view and respond to patient messages, it would be preferable to arrange for electronic cross-coverage on weekends and while surgeons are away.

## Study limitations

Although subjects for the e-monitoring group were accrued in a prospective manner, patients were not selected randomly, and as a result the study is subject to bias. Also, because the control group was studied retrospectively, it was not possible to reliably assess patient satisfaction with conventional follow-up and compare this for the two groups.

The patients in the conventional follow-up group were older than

patients in the e-monitoring group, which may have had an impact on the number of unscheduled visits to the ED. The mean age of the eight patients in the conventional follow-up group who had unscheduled visits was 65.8 compared with 65.5 in the conventional follow-up group as a whole ( $P=.903$ ).

A confounding factor in the control group surgeries was a higher number of bilateral mastectomies with a corresponding increase in operative time. Two of the four bilateral mastectomy patients each had at least one unscheduled visit to the ED. If the bilateral mastectomies are excluded from the analysis, the number of unscheduled visits made by conventional follow-up patients is still significantly higher (6 visits for 33 surgeries in the control group versus 1 visit for 35 surgeries in the e-monitoring group;  $P=.038$ ).

## Summary

In this study, electronic wound monitoring was associated with significantly fewer unscheduled visits to the emergency department, a high degree of patient satisfaction, and a likely reduction in cost to the health care system. These results justify conducting a multicentre, prospective, randomized controlled study to learn more about electronic monitoring.

## Competing interests

At the time this article was submitted to the *BCMJ*, Dr Hwang owned shares in QHR, the health care technology company responsible for the Medeo virtual care platform. Dr Hwang does not currently own shares in QHR.

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