Smartphone Application for Post-operative Gastric Patients: Surgery Diary

Jin-Ming Wu
Department of Surgery of National Taiwan University Hospital
Graduate Institute of Biomedical Electronics and Bioinformatics of National Taiwan University
Taipei, Taiwan
e-mail: kptkptkpt@yahoo.com.tw

Te-Wei Ho, Xing-Yu Su
Graduate Institute of Biomedical Electronics and Bioinformatics of National Taiwan University
Taipei, Taiwan
e-mail: skbaskba@gmail.com, aipeople0513@gmail.com

Ming-Tsan Lin
Department of Surgery of National Taiwan University Hospital
Taipei, Taiwan
e-mail: linmt@ntu.edu.tw

Feipei Lai
Graduate Institute of Biomedical Electronics and Bioinformatics of National Taiwan University
Department of Computer Science and Information Engineering of National Taiwan University
Department of Electrical Engineering of National Taiwan University
Taipei, Taiwan
e-mail: flai@ntu.edu.tw

***Abstract*—Gastric cancer is one of the most common gastrointestinal diseases around the world. In general, surgical resection is the only intervention. Surgical gastric cancer patients may suffer from malnutrition, which can be associated with gastrointestinal complications, surgical stress, and cancer cachexia. Malnourished patients typically have poor oncological outcomes and a decreased quality of life. To hasten the recovery of post-gastrectomy patients, we developed a smartphone application (app) that implements the functions of nutrition monitoring, medical information management, follow-up of drains, and wound care. This app is written using objective-C and the iOS (previously iPhone OS) 6.1 SDK (Software Development Kit), which provides iOS 5.1 and later compatibility. To integrate users' records, mySQL was used for data management and computing. Moreover, this app includes clinical rule support that informs patients of severe body weight loss or possible internal bleeding. Using this app, patients are able to monitor their general condition, wound, and nutritional status by themselves. Based on the preliminary analysis from users, this app is considered a useful tool that users can use it to reduce the impact on body weight loss significantly. More importantly, this app acquires a high degree of support with 93.3 percent from users.**

Keywords-smartphone; application; gastric cancer; surgery

I. INTRODUCTION

Gastric cancer is the fourth most common cancer in the world [1]. In general, radical surgical resection is the only potentially curative treatment. However, most patients are usually diagnosed at an advanced stage owing to occult clinical presentation, and the five-year survival rate is less than 10 percent. Moreover, patients diagnosed with gastric cancer have a higher proportion of malnutrition (60 to 85 percent) [2], which may be related to a cancer-inducing gastrointestinal obstruction, cancer cachexia, or perioperative stress. Surgical patients may suffer from wound pain, anorexia, malaise, and gastrointestinal digestion disorders [3], which can also result in malnutrition. Reduced gastric functioning is associated with both diminished food intake and malabsorption of vitamins, fats, and proteins [4]. If the malnourished status is not recognized, patients will have inferior clinical outcomes and a decreased quality of life compared to those with suitable nutritional status [5][6].

With the popularity of smartphones, people have changed their method of accessing information. There is an increased interest in smartphone applications (apps) as a tool for medical professionals and patients to deliver medical information. It is reported that the market for mobile health apps for smartphones and tablets will be US $26 billion by 2017 [7]. As of 2013, there are an estimated forty thousand medical apps available on the market. It has been indicated by previous studies that smartphone apps for patient self-monitoring are feasible [8][9]. Hence, for the purpose of the high-quality care, the aim of this study was to create a smartphone app, including perioperative medical education, long-term follow-up of body weight implemented with clinical rule support, and wound care for post-operative gastric cancer patients. In addition, we evaluate the utility of this app and assess the feasibility of it.

The construction of this paper is organized as follows: 1) *System Architecture*, where the development of the application system is presented in detail; 2) *Result*, which presents the demographics of users, and the results obtained for the assessment for the app; and 3) *Conclusion and Future Work*, which resumes this paper by summarizing our contributions and discussing directions for future work.

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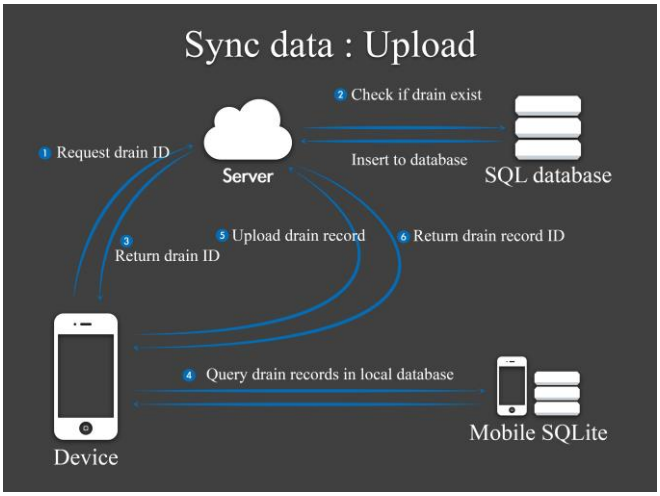

Figure 1. The architecture of application system

II. SYSTEM ARCHITECTURE

This app was developed using the objective-C language and iOS (previously iPhone OS) 6.1 SDK (Software Development Kit), which provides iOS 5.1 and later compatibility. To integrate users' records, mySQL was used for data management and computing. Besides, the app automatically synchronizes data with a server-side database implemented by the C# language in a .NET framework. To provide web services, a Microsoft SQL (Structured Query Language) server is utilized for data storage in the study. Figure 1 shows the architecture of the application system.

A. *Interfaces Implementation*

We divided the major functions of this app into six interfaces, such as home page, my weight, my drains, wound pictures, surgery, and symptoms.

1) Home page: The interface of the home page (Figure 2), which is grouped from two parts. The first part shows the summary of patient's health status and the days after surgery. According to the last uploaded data from patients, we divide the summary into three categories by the rules of physicians' suggestions. Hence, the categories are defined as "well general condition", "fair general condition", and "poor general condition", respectively. The well general condition means normal in both weight and drain. The fair general condition means abnormal in body weight decreasing by 5 to 10 percent. The poor general condition means either the last body weight decreasing more than 10 percent or the last drain fluid turning red. With these alarms, the patient could contact with case managers, and receive appropriate suggestions from them. Besides, we employ a corresponding facial expression icon to easily represent a condition that the patient has. Another part of the home page represents the shortcut of each function, such as my weight, my drains, symptoms, surgery, and wound pictures.

2) My weight: For the purpose of continual care, we recommend patients to upload the body weight each day. The interface will illustrate the weight with a trend by one week and three months (Figure 3; left), then we can easily undertake observation in the variance of body weight on it. Besides using the clinical rule support, the app

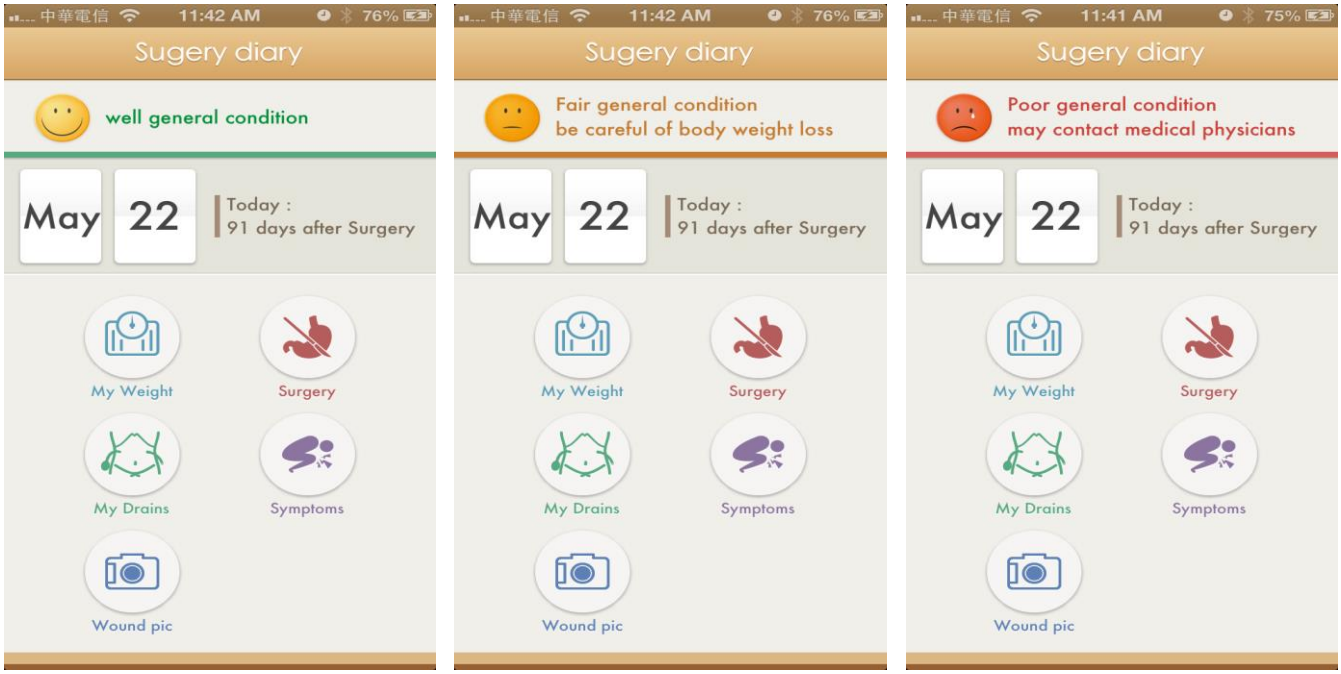

Figure 2. The home page of smartphone application

Figure 3. Trend of weight records by 1 week and 3 months

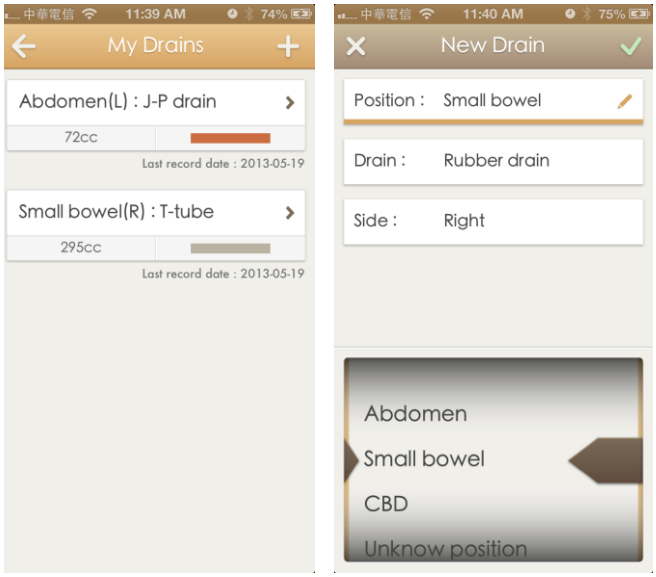

Figure 4. Select the characteristic of drains

automatically calculates the change in body weight over the past three months or the date of operation. Specifically, we define the orange sign to express the patient's body weight decreases by 5 to 10 percent, more than 10 percent for red and normal range (less than 5 percent) for green, respectively (Figure 3; right). Likewise, patients could receive the alert message on the homepage due to the decline in body weight. Through these manners, it may be able to give patients assistance to know their body weight condition much easier.

3) My drains: The gastrectomy is a complex operation, which may be associated with complications such as leakage. Previously, the patient recorded the data on paper, which was not convenient or reliable. With the app, the patient can easily record the drain information by himself/herself. First, the patient needs to select the feature of drains at first time. What is more, the patient must choice the kind of drains by their own selection with the position, type and body side. Also, he/she can add a new drain with the same setting format about last time (Figure 4). Next, the patient could input the daily color and volume of any drain by color charts, including red, orange, green, yellow, and gray (Figure 5; right). Generally, these colors are the most commonly used for recording of drain fluids. Meanwhile, we draw the trend and the spot according to the historical records (Figure 5; left). The convenience of this graph is similar to that of weight graph. The patient can readily gain insight into the trend and the color points. It is worth noting that if the drain fluid turns red, it might be the symbol of internal bleeding, then both the patient and medical practitioners could receive alarm message from the system.

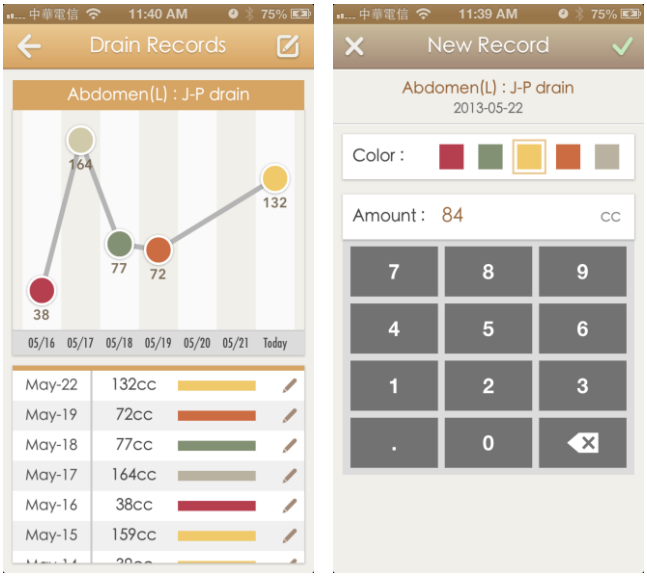

Figure 5. The interface of drain records

4) Wound pictures: The patient can take pictures of the wound and drains if necessary. The pictures are sent to the web server, where the medical staff can check the condition of the wound. This function is also integrated with the telecare center at the National Taiwan University Hospital (NTUH). If the wound is infected, the medical staff can call the patient and pursue medical treatment.

5) Surgery: This section provides the prescriptions of surgery that the patient has. The patient can understand the detail information about the disease and surgery.

6) Symptoms: To give appropriate suggestions of symptoms that patients may encounter after the gastrectomy, the app automatically calculates the interval between the date of the operation and the present day. Next, according to

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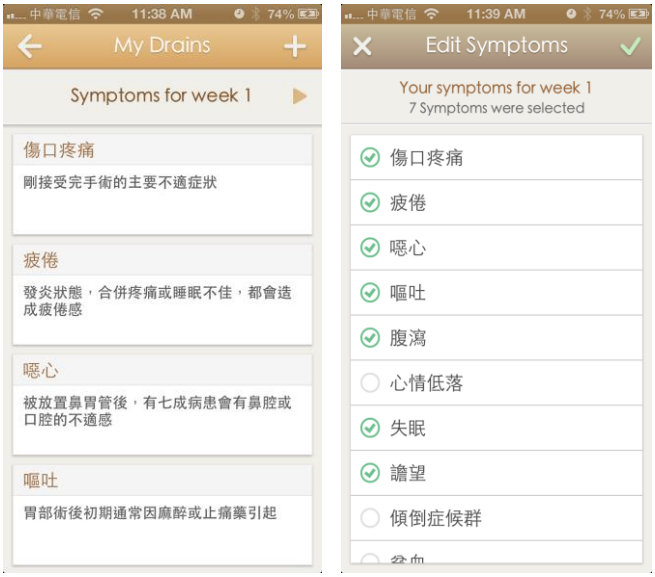

Figure 6. The interface of symptoms

TABLE I. CHARACTERISTICS OF PATIENTS BETWEEN GROUPS

Variable	App group (n=15)	Control group (n=15)	*P* value
Gender (male: female)	7:8	8:7	0.910
Age (years)	61.6±12.1	60.7±18.1	0.876
Body mass index	23.4±3.6	22.7±3.9	0.611
Comorbidity	8	4	0.135
Indication of gastric surgery Gastric cancer Gastric tumor	 12 3	 12 3	0.999
Pathological staging Stage Ⅰ Stage Ⅱ Stage Ⅲ Stage Ⅳ	 5 6 4 0	 6 5 4 0	0.912
Pre-operative chemotherapy	0	0	0.999
Post-operative chemotherapy	2	3	0.921

the interval days, the function provides patients the information regarding typical weekly discomfort after the surgery (Figure 6; left). In addition, we offer more than ten general symptoms such as wound pain, fatigue, diarrhea, insomnia, and so forth. Patients can simply add or remove their specific symptoms with the detail information through the interface (Figure 6; right). Thus, the system would count the number of symptoms over time.

B. Web Service and Auto Notification Service

We designed and developed a platform for patients and medical staff. On the platform, they can review follow all of the historical upload record, such as weight, drain, symptoms, and wound pictures. The patient can access the platform to input their post-operative data if a smartphone is not available (not shown here). In addition, the web service will automatically send a cell phone message to the medical staff when the patient uploads wound pictures. With this service, medical professionals can immediately check the wound condition, and notify the patient if the wound infection should be investigated.

C. Assessment of the App Performance

We conducted a simple questionnaire to evaluate the usefulness of this app from users at the National Taiwan University Hospital. Besides, In order to compare with the app users group, we retrospectively collected subjects undergoing gastrectomy as a control group. More importantly, for the assessment of prognosis in both groups, we also collected the medical record in terms of outpatient clinic (OPC) visits, re-admission visits, and emergency room visits. In order to make a comparison between the app group and the control group, all values were expressed as mean with their associated standard deviations or frequency. The Mann-Whitney U test was used for continuous variables, and the Fisher's exact test was used for categorical variables. Data analyses were performed using SPSS software version 15.0. A 2-sided *P* value of less than 0.05 was considered statistically significant.

III. RESULTS

This app had been available since late June, 2013 on Apple App Store. There were 15 consecutive patients at NTUH accessing this app (app group). Besides, we retrospectively collected 15 cases undergoing gastrectomy as a control group. The demographics of both groups are shown in Table 1. Mean age of the app group was 61.6±12.1 years, and that of the control group was 60.7±18.1 years. The mean body mass index of app group and control group were 23.4±3.6 and 22.7±3.9, respectively. Even though this study design did not use randomization, the two groups were similar in all variables with non-significant difference. For the clinical results (Table 2), the app group had the less proportion of body weight loss percentages compared to control group during six-month follow up (4.6±0.5 vs. 11.4± 1.2, $P < 0.01$). However, the patients of app group had more out-patient clinic (OPC) visits than the control group (10.8± 1.4 vs. 8.3±1.7, $P < 0.01$). With this application, the patients developing body weight loss more than 5 percent three months after operation could receive the warning from the app, which also inform the medical staff to do nutritional assessment and intervention for the malnourished cases, such as consultant of dietician. After all, nearly 93.3 percent of users are willing to recommend this app to others. As a result, the patients of app group visited the OPC more times to undergo the nutritional evaluation to achieve early diagnosis and early intervention.

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TABLE II. THE CLINICAL OUTCOMES BETWEEN TWO GROUPS

Variable	App group (n=15)	Control group (n=15)	*P* value
Percentages of body weight loss (compared to pre-operative status)	4.6±0.5	11.4±1.2	＜0.01
Number of outpatient clinic (OPC) visit	10.8±1.4	8.3±1.7	＜0.01
Re-admission	2 (13.3%)	3 (20.0%)	0.598
Emergency room visit	0 (0.0%)	1 (6.7%)	0.999
Would you recommend this App to others? Yes No	 14 (93.3%) 1 (6.7%)	-	-

IV. CONCLUSIONS AND FUTURE WORK

Based on the preliminary analysis from users, this app is considered a useful tool that users can use it to reduce the impact on body weight loss significantly. More importantly, this app acquires a high degree of support with 93.3 percent from users. Smartphones have become increasingly popular with both medical professionals and patients in recent years. For this reason, the number of associated applications is dramatically increasing. The quality of the rapidly growing amount of information in these medical apps; however, could be inconsistent. It is well-documented that only 55.8 percent of the apps are associated with scientifically validated data, with the best quality information being developed by healthcare professionals or organizations [10]. To develop this app, we worked with the medical surgical staff and dieticians at the NTUH. The information, which consists of not only the educational data but also the clinical rules, is considered accurate and reliable.

In this fast-changing arena, human communication and healthcare information-gathering methods have changed. With diverse online social networking services such as Facebook and YouTube, people are beginning to access these services to manage their health condition [11][12]. In the near future, combined services (the app and the platform) may become the leading trend in health care.

However, there are several limitations or special considerations in this study. First, this app is not regulated by the medical authorities in Taiwan. The US Food and Drug Administration (FDA) has set some regulations to oversee medical apps that contain medical device accessory functionality or transform mobile communications into regulated medical devices [13]. In the future, wishing to augment the care provider in the healthcare process decisions, further studies are needed to integrate the medical record and communication services to the platform. Additionally, additional time and cases are required to prove if this app has clinical benefits such as improved quality of life or improved nutritional status.

This app is implemented by information technology specialists, and it is also co-designed by medical staff with clinical rule support. It does not, even so, take the place of clinical intervention and judgment. In addition, patients input and store their information in the app, which is then transferred to a web server. The protection of patient data, which may be vulnerable to intentional or unintentional attack, is very important. In this study, we designed and implemented three secure layers to protect the privacy of the patients and their data on the web server as described previously [14].

This app is a feasible software solution for gastric cancer patients to record their post-operative information and as an alternative tool for self-care. However, the long-term clinical value must be validated in a future study, and number of patients are considered to be necessary to properly evaluate its effectiveness.

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