MEDINFO 2021: One World, One Health – Global Partnership for Digital Innovation
P. Otero et al. (Eds.)

doi:10.3233/SHTI220245

Using Artificial Intelligence for the Early Detection of Micro-Progression of Pressure Injuries in Hospitalized Patients: A Preliminary Nursing Perspective Evaluation

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Abstract

This study established a predictive model for the early detection of micro-progression of pressure injuries (PIs) from the perspective of nurses. An easy and programing-free artificial intelligence modeling tool with professional evaluation capability and it performed independently by nurses was used for this purpose. In the preliminary evaluation, the model achieved an accuracy of 89%. It can bring positive benefits to clinical care. Only the overfitting issue and image subtraction method remain to be addressed.

Keywords:

Pressure injury, micro-progression, artificial intelligence

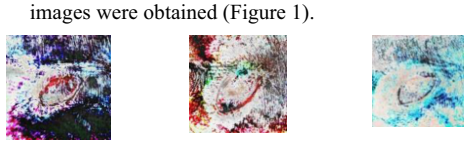
Introduction

Pressure injury (PI), is an important measurement of nursing quality and often occurs within the first 24–96 hours of admission to hospital [5]. PI in hospitalized patients is associated with prolonged healing and increased risk of amputation and infection, which not only affect the patient's quality of life but are also life-threatening [2, 5], pose a great challenge to nurses' clinical care [2], and increase the cost of clinical care [1, 3]. PI progression is measured by the proportion of characteristics regarding unhealed PIs, i.e. improvement toward healing, deterioration, or maintenance, during the period from admission to discharge or death over time and is an important determining factor for treatment and prognosis [2]. Medical images are important visual recordings. Analysis of medical images collected non-invasively with the aid of artificial intelligence (AI) technology allows the objective observation of inconspicuous changes invisible to the naked eye. The analysis further facilitates early detection of the progression of PI characteristics, allowing the timely adjustment of medical care measures by the nurses without harming the patients [4]. This study aims to establish a predictive model for the early detection of micro-progression of PIs from the perspective of nurses. The aim is helping the clinical nurses to evaluate and monitor the effectiveness of PI care and enhance the quality of care.

Methods

The study was conducted from August 26, 2020 to January 23, 2021 at an internal medicine ward of a medical center in Northern Taiwan, including 31 subjects who were hospitalized with sacrum PIs.

1. **Design of Standard Scales:** To control the content, angle, and distance in the image collection, the investigator prepared 15 different (1~15 cm^2) standard scales (small frames, to collect only PIs).
2. **Image Collection:** A senior nurse determined the standard scale size at the initial PI evaluation. The scale was placed on the PI after wound care each day, and a photo with the small frames was taken with a smart phone (iPhone7 Plus); a total of 377 photos were collected.
3. **Definition of PI micro-progression**: The inconspicuous changes in PI characteristics before and after 24 hours were classified as "better," "worse," and "same."
4. **Image Pairing:** The images taken before and after 24 hours were matched in pairs; thus, 346 pairs were obtained for standard scale.
5. **Image Labeling:** Three senior wound care experts evaluated and labeled the image pairs. The label result was determined by the majority vote. In the case that each category received one vote, the final decision was made by a plastic and reconstructive surgeon and the final result was taken as the gold standard.
6. **Image Pre-processing:** The "perspective crop" was run in photopea, an online photo editor, with two paired standard scale photos. It was then visually ensured that the two paired photos shared a common positioning point by rotation and trimming, and two new images were obtained as output after editing. The two new images were loaded into the software "Python Pillow Library" and "resize" (2000 x 2000) was run to align them. Then, "subtraction" (today's image pixels-yesterday's image pixels) was run to form a micro-progression image. A total of 346 micro-progression images were obtained (Figure 1).



Better Worse Same

Figure 1 - Subtraction Image

7. **Model Establishment:** For model establishment, 90% (312 images) of the micro-progression images were used as a training dataset and the other 10% (34 images) was used as a validation dataset. The training

dataset was loaded into a Teachable machine (TM) for model training. After model training, the validation dataset was imported into the model to verify the performance of the model.

Results

The average age of the 31 subjects was 72.80 ± 13.21 years, and the average length of hospital stay was 23.58 ± 19.42 days. Most patients had stage 2 PI (16, 51.6%), and 10 (3.1%) had unstageable PI. The largest PI had an area of 11 x 12 cm and the smallest 1 x 1.5 cm. In the 346 pairs, 146 pairs were labeled as better and 84 pairs were labeled as worse (Table 1).

Table 1 - Labeling Results

	Pair	Better	Worse	Same
Labeling Results	346	146	84	116

Model Performance: In the test dataset, class 3 demonstrated the highest accuracy of 89%, and the accuracy of the validation dataset was 59% (Table 2).

Table 2 - Model Performance Eevaluation

	Image	Sensitivity	Specificity	FPR	PPV	Accuracy	F1-score
Test	46	1.00	0.82	0.18	0.78	0.89	0.88
Valid	34	0.29	0.80	0.20	0.50	0.59	0.36

FPR= false positive rate
PPV= positive predictive value

Discussion

In the preliminary evaluation, the model achieved an accuracy of 89%. However, the accuracy for the validation data was much lower than that for the test data (Table 2), possibly due to overfitting caused by the small sample size of data. Besides, there were limitations from the TM autoadjusting the image size to 200x200, which made the micro-progression images 10 times smaller and affected model training effectiveness. Furthermore, during imaging labeling and pre-processing, the study found that the naked eye could automatically filter out image brightness and other details unrelated to PI and provide categorization according to PI characteristics. However, the new image generated by image pixel subtraction was not able to achieve characteristic categorization, which affected the model's training ability. In the future, more PI images should be continuously collected to increase the dataset size and a more suitable image processing method should be used to optimize the model training.

In this study, majority of progression images were labeled as "better", indicating that image recording offers positive clinical benefits by enhancing the alertness of the care-related personnel to PIs and paying more attention to the implementation of care measures. It is recommended that PI image should be included in nursing records.

Conclusions

This study preliminarily evaluated a predictive model for the early detection of micro-progression of PIs. The model was established using an easy and programing-free AI modeling tool. The detection was performed independently by nurses without the assistance of information technology personnel. The tool had professional evaluation capability. PI image record can bring positive benefits to clinical care.

Acknowledgements

This study was financially supported by the research funding of Far Eastern Memorial Hospital.

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