Does infrared visualization improve selection of venipuncture sites for indwelling needle at the forearm in second-year nursing students?

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ABSTRACT

Objectives: To evaluate the effectiveness of a vein visualization display system using near-infrared light ("Vein Display") for the safe and proper selection of venipuncture sites for indwelling needle placement in the forearm.
Methods: Ten second year nursing students were recruited to apply an indwelling needle line with and without Vein Display. Another ten participants were recruited from various faculty to serve as patients. The quality of the venipuncture procedure at various selected sites was evaluated according to a scale developed by the authors. Time, scores and patterns of puncture-site selection were compared with respect to three different methods: [1] attempt 1 (tourniquet only), [2] attempt 2 (Vein Display only) and [3] attempt 3 (both). To validate the effectiveness of Vein Display, 52 trials were conducted in total.
Results: We found that venipuncture site selection time was significantly improved with the Vein Display, particularly in the case of difficult to administer venipuncture sites. Overall, we found no significant difference with respect to venipuncture quality, as determined by our scale.
Conclusion: These results suggest that equipment such as the Vein Display can contribute immensely to the improvement of practical skills, such as venipuncture, especially in the context of elderly patients.
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Introduction

Throughout the world, human resource development and certification systems for advance practice nurses (APN) are becoming more common, with the United States leading the way. The increased attention being received by APN has been driven by and large by changing societal needs, particularly as it concerns changes in lifestyle and population aging (Collins-Bride and Saxe, 2013). Under this paradigm, the standard for nursing education has been transitioning to post-graduate master's programs and beyond (International Council of Nurses, 2002; American Association of College of Nursing, 2011). In Japan, the Certified Nurse Specialist (CNS) system was established in 1995. However it is widely acknowledged that Japan lags behind global standards, particularly with respect to the systems needed to support increased autonomy and expanded roles for nurses (Uchinuno, 2014; Tanaka, 2014). In

order to catch up, the capacity of nursing education in Japan to teach advanced knowledge and skills must be improved, with particular emphasis on the transition-to-work system. Effective use of high function simulators has the potential to play a pivotal role in this regard, especially with respect to advanced skills training (Inoue, 2014).

Japan is currently undergoing a major social crisis, largely due to the accelerated aging of the Japanese population. To address this, the Japanese government instituted reforms at the turn of the millennium to provide long-term, home-based care to the increasing numbers of elderly patients (Horton, 2010). Hence, there is a demand for a shift to "community-oriented medical care" for providing comprehensive care supported with medical and nursing resources available in the community (Arai et al., 2015). The Long-Term Care Insurance system covers the long-term care of the elderly which was previously provided partly through the health insurance system and partly by the welfare measures for the elderly. National Institute of Population and Social Security Research reported the number of persons certified for the long-term care increased by more than 140% from 2000 (2.18 million) to 2013 (5.64 million). As a result, the number of patients requiring

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medical care services at home has been rapidly increasing, and is expected to increase demands for home-care nursing in the future (Asahara et al., 1999; National Institute of Population and Social Security Research, 2014). Accordingly, the demand for nurses capable of independently providing basic primary care has been increasing globally (Wang and Tsay, 2012).

Venipuncture is one of the most common clinical procedures in healthcare. However establishing peripheral intravenous access is challenging, particularly in pediatric and geriatric patients with fragile or hidden veins. Insufficient venipuncture skills or difficult intravenous access results in the need for multiple needle insertion. Failure rates are reported to occur in 30—50% in difficult patients (Walsh, 2008).

Multiple venipuncture attempts are associated with an increased incidence of extravasation, vascular perforation causing hematoma or hemorrhage, and phlebitis. This not only heightens patient anxiety and suffering, but failed attempts can also compromise the trust and confidence a patient has in the nursing staff (Walsh, 2008).

Until the Japanese government changed the guidelines regarding venipuncture by nurses in 2002, it was clearly defined that venipuncture was beyond the scope of practice for registered nurses. Since then, there have been many recommendations regarding appropriate protocols for making clinical venipuncture a part of nursing education in Japan. This has also partly been driven by calls for increased clinical cost efficiencies and governmental regulation. In 2003, the Japanese Nursing Association released the Guidelines for the Practice of Venipuncture, which defined four practical levels of venipuncture by nurses. In accordance with the Guidelines, each hospital has been actively responding by developing programs for venipuncture and fluid infusion management.

This, however, hasn't come without its challenges.Across the globe, nursing education has been compelled to focus increasingly on practical skills and knowledge, such as those necessary for safe and proper venipuncture. A 2012 review reported numerous cases of peripheral nerve injuries due to improper venipuncture (Stevens et al., 2012). And since then, numerous other reports have emerged describing the severity of this problem (Ramos, 2014). Based on these statistics alone, however, the magnitude of this issue is very likely to have been underestimated (Moore and Stringer, 2012). Indeed, within the US alone, venipuncture has been reported to be the number one cause of injury among patients (Walsh, 2008). This reality has lead to many efforts to identify optimal venipuncture technique (Parisotto et al., 2014). In addition, there have been many reports on the development of various tools and methods for improving the success rate of venipuncture, in practice (Balter et al., 2015; Juric et al., 2014). Such issues are also relevant to nursing practice and education in Japan, where a review of the Japanese literature (Takahashi et al., 2011, 2013) and (Sugama, 2012) consistently demonstrated that creative interventions like the use of equipment to show subcutaneous vessels and nerves, are a necessity, especially for novice learners. This is especially true in cases requiring specialized care, such as with elderly or pediatric patients, whose veins are often difficulty to palpate, or patients who are obese or darker-skinned, whose veins are difficult to identify (Walsh, 2008).

It has been demonstrated that improved training and education reduces the rate of error when performing venipuncture, in practice (Lima-Oliveira et al., 2012). However, in Japan, nurses are not allowed to practice on humans until they have become licensed, and so the present curriculum for undergraduate nursing doesn't include live venipuncture training. For example, at our university, second year nursing students are obliged to take the course "Nursing Procedure III", which includes lectures (90—135 min each) and practical sessions (135 min × 2 times) for venipuncture. This course uses a type of simulator model for the forearm; however, the simulator is not realistic in some areas; for example, there is no effect on applying or removing a tourniquet. Consequently, nursing students can not experience the engorgement of blood vessels and bleeding upon removal of the needle. For that reason, it is vitally important for instructors to check that students carried out the procedure precisely as instructed. To address this, we are consistently searching for new methods or technologies to improve the quality of venipuncture education, given the practical limitations here in Japan.

To this end, we were recently given a chance to test-out a new vein visualization display system (tentatively referred to as "Vein Display") that uses near-infrared light for displaying subcutaneous veins. Numerous recent studies have demonstrated the effectiveness of various techniques or technologies to improve vein visualization. The oldest such technique is referred to as transillumination and involves the placement of light sources under or around an extremity (John, 2007). More recently, ultrasound, which is becoming increasingly recommended in central venous catheter placement (Karakitsos et al., 2006), has been increasingly demonstrated to improve peripheral venipuncture success under various circumstances (Brannam et al., 2004; Schnadower et al., 2007). Near-infrared visualization is a more recent addition and involves the direct illumination and visualization of the venipuncture site. It is regarded as one of the most promising methods for improved venipuncture success rates, due to improved vein identification times, fewer number of required attempts, and shorter time for IV placement (Juric et al., 2014). It has also been noted to be effective for patients who veins are typically difficult to palpate or identify (de Graaff et al., 2013; Cuper et al., 2012).

The purpose of this study was to evaluate the effectiveness of the Vein Display for the selection of venipuncture sites for indwelling needle placement in the forearm, in the context of a clinical skills training program for second year nurses. This paper describes the effectiveness of the Vein Display technology for enhancing learning for novice students and extends current knowledge regarding the application of this technology in nursing education, to ensure the provision safe and precise care of patients in an increasingly aging society.

Methods

Subjects

Ten participants were recruited from among 80 second year nursing students to apply an indwelling needle line with and without infrared visualization (implementation subjects). Another ten participants (5 males and 5 females) were recruited from various faculty across Mie University (age 20—38, 24.9 ± 5.5 y.o.) to serve as patients (patient's-role subjects) (Table 1). Both the 10

Table 1
Age and sex of the patient's role subjects (n = 10).

Patient's role subjects	Age	Sex
A	22	Male
B	26	Female
C	30	Male
D	22	Male
E	21	Male
F	26	Female
G	38	Male
H	20	Female
I	21	Female
J	23	Female