Peripheral intravenous catheter insertion and therapy administration: simulator learning

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Abstract. *Background and aim:* Obtaining, positioning, and managing intravenous access is complex but common procedure in nursing care practice. Learning the right knowledge and skills during basic nurse education is an essential goal. The use of simulators allows for a better acquisition of skills, guaranteeing safety for patients and nursing students. However, the literature is still lacking on the use of simulation for intravenous cannulation procedures and device management, presenting few conflicting results. The aim of this study was to examine the effect of simulator-based learning on vascular access management in a population of nursing students. *Methods:* Using a comparative observational study design we evaluated the effect of simulator learning on vascular access management in a nursing student population. *Results:* The differences between the scores at T1 between the groups of students are significant for obtaining vascular access with relative management of the device and intravenous therapy ($t = 3.062$, $p = 0.001$), while at T0, albeit with strong differences in scores means ($t = 0.061$, $p = 0.871$) are not statistically significant. Early use of the simulator is also fundamental over time ($t = 5.362$, $p = 0.001$). Furthermore, the satisfaction noted by the students during the clinical simulations improves with the increase in the number of the same, as it can influence the single performance. *Conclusions:* Nursing training based on the use of simulators favors a better acquisition of skills compared to traditional didactic. (www.actabiomedica.it)

Key words: simulator, mannequin, intravenous therapy, nursing students, learning

Introduction

Obtaining intravenous access, managing intravenous access, and administering intravenous drug therapy are complex procedures (1, 2) commonly carried out in daily care practice (2, 3) under the direct responsibility of nurses (1, 4). These procedures are not free from risks and complications that may jeopardize the health and sometimes even the life of the patient (5). The most common complications presented in the scientific literature include phlebitis, vascular access occlusion, device displacement and device-related infections (6). These complications had found in over 30% of intravenous access devices implemented, and the mere presence of one of these complications leads to premature removal of vascular access (7). After initial vascular access placement, any premature removal generates an increase in costs and the possibility of resorting to more expensive and invasive procedures (6). The literature shows that the overall failure rate of intravenous access placement and management is over 30% (7). Among the main causes of failure leading to premature removal of devices that guarantee vascular access is a deficit of knowledge and skills on the part of nurses (7). There is evidence that device insertion knowledge, confidence and skill are related to first-time placement success (8, 9) and that the risk of complications is reduced when experienced nurses perform the insertions (7).

It is therefore essential to begin improving the ability to manage the entire intravenous therapy procedure – from the positioning of the device and its management up to its 'normal' removal –in the basic training of nurses (5) to train professionals with adequate knowledge and skills and ensure effective and efficient interventions. This could reduce the complications and health costs associated with this procedure (10, 11). It is therefore necessary to ensure that nursing students can adequately develop these skills (5).

In traditional nursing learning programs, due to the large number of students and the requirement to ensure patient safety, the development of these skills in purely clinical settings can be challenging (12). Furthermore, this situation is worse by the constant decrease in hospital beds and the chronic shortage of nursing staff (13, 14).

Simulation is a teaching approach that complements traditionally delivered education by enabling students to develop knowledge and skills in a safe environment (2). The use of simulation laboratories is now an integral part of medical and nursing education (15). These laboratories reproduce situations like what is present daily in clinical practice, (4) allowing nursing students to acquire competencies and implement their skills before practicing on real patients (16). This ensures both correct integration between theory and practice (17) and patient safety (18-20). A successful integration of theoretical learning and practical experience greatly increases learning potential (21). Indeed, the literature shows how the use of simulators has a significant influence on learning (22). Simulation labs allow common, non-clinical practice situations to be reproduced in a low-risk environment, (5) which does not generate pressure on students (23). In this pedagogical context, the students are supervised and supported by a tutor (24) who provides indications and specific educational interventions (15). This leaves the students free from pressure and from the fear of making a mistake or causing harm to the patient (25) while strengthening their clinical skills (26). The use of simulation leads to an increase in levels of satisfaction and confidence on the part of the students, yielding a reduction in anxiety before approaching clinical practice in internships and a better understanding of the involved procedures (23, 27); all of this can be correlated with an improvement in care outcomes (23).

While simulation has been used for both complex and simple medical procedures, yielding skill improvement in both experienced and inexperienced subjects, (15) little has been published on the use of simulation for intravenous cannulation procedures and device management, (28, 29) particularly in the Italian context (2).

The aim of this study was to examine the effect of simulator-based learning on vascular access management in a population of nursing students.

Methods

Design

This study evaluated the effectiveness of an educational intervention in which simulations were performed to help teach the participants how to find and manage vascular access. A comparative design was used to conduct this study.

Setting

In this course of the study, professional training laboratories were set up fort the use of simulators. Students were asked to participate voluntarily in the study after the internal university committee approval.

Sample

Our sample consisted of students who were about to learn these skills for the first time in the Nursing Course at Magna Graecia University in Catanzaro. All students received a scheduled learning program, then two groups of students were randomized to receive practice training (experimental group) with the use of a simulator tool (here defined as anatomical arm) immediately after it or to not receive practice training (Control Group).

The minimum sample size required to conduct the study was calculated using the software G*Power 3.1, and the number of participants from a t-test of both groups was calculated using a two-tailed test, a significance level of α=0.05, an effect size of 0.95 and a power of 0.80, requiring a minimum of 28 students per arm.

Thirty students per arm were recruited out of a total number of 60 nursing students.

Participation procedures

All participants completed the study without withdrawing. Both groups completed theoretical training on vascular access placement and management through a standardized frontal lesson that included videos. In this phase the students were present at the same time, in the same classroom, and with the same teacher. At the end of the lesson, the students belonging to the experimental group went to training laboratory room where they carried out exercises on the positioning of a vascular access device in an anatomical arm and on the consequent management of the intravenous therapy. A tutor was present and guided the exercises, explaining the procedure and clarifying any errors or doubts raised by the students. Subsequently, it was asked to proceed to find an intravenous access on an anatomical arm to all students. This time was defined as T0.

After 5 days all the students of both groups actively participated in a practical lesson in the internship laboratory related to proceed with vascular access and intravenous therapy administration. At the end of this session, all students were asked to proceed with finding a vascular access and administering intravenous therapy. This time was defined as T1. In each group, a different anatomical arm was used (compared to the one used previously). Students' performances were evaluated, and in cases of error, the procedure was repeated up to a maximum of three times.

Instrument

An *ad hoc* socio-demographic questionnaire was created to collect the socio-demographic data of the participants.

A checklist to evaluate knowledge of how to insert a vascular access and administer intravenous therapy was designed by the researchers with reference to recent scientific evidence (e.g.: we have a vial of penicillin with a concentration of 1,500,000 IU diluted in 6 ml. We must administer 800,000 IU to patient. Calculate how many ml must be administered) (30) and it was used in both groups.

To evaluate student satisfaction during the clinical simulations, the Satisfaction with Simulation Experience (SSE) Italian version scale was used (21) which refers to the original English version (31). This scale allows the satisfaction of nursing students to be evaluated after training using simulators, high-fidelity or otherwise (31). This tool represents, to date, the only scale validated in Italian (SSE-ITA) that is suitable for assessing student satisfaction after simulations (21). The SSE is a 5-point Likert scale (ranging from 'strongly disagree' to 'completely agree') made up of 18 items that investigates three dimensions of the simulation experience: nine items make up the first area, 'debriefing and reflections', which evaluates the validity and the importance of the debriefing (e.g.: "Reflections and discussion on how simulation reinforced my learning"); the second area is evaluated through five items that investigate the ability to develop "clinical reasoning" (e.g.: "The simulation developed my decision-making skills in clinic"); and the third area evaluates, by four items, evaluates the "clinical learning" (e.g.: "The simulation tested my clinical ability"). The scale had I-CVI values all higher than 0.80, S-CVI, obtained from the mean of all coefficients, of 0.94. The Reliability Coefficient, regarding stability, was r=0.88 (21).

Internal consistency was good for the "Debriefing and reflections" block (α=0.745) and both acceptable for the "Clinical reasoning" block (α=0.69) and "Clinical learning" block (α=0.635) (21).

In our study this questionnaire showed a similar internal consistency for the "Debriefing and reflections" block (α=0.70), for the "Clinical reasoning" block (α=0.64), for "Clinical learning" block (α=0.60) and similar reliability coefficient (r=0.81).

Sociodemographic data were collected at the beginning of the first lesson. Evaluations of the correct positioning and management of the devices for obtaining intravenous access and the correct execution of the therapy were conducted at T0 and T1 in both groups. The SSE was administered at T0 for the experimental group only and at T1 for both groups.

Data analyses strategies

Data were presented as numbers or percentages for categorical variables. Continuous data are expressed as the mean ± standard deviation (SD); a chi-square test (χ^2 test) was performed to evaluate significant differences of proportions or percentages between two groups. Test for normal distribution was performed by Shapiro-Wilk test. Particularly if Shapiro-Wilk test was not significant, the T test was performed. In addiction Levene's Test for equality of variances was performed. If the Levene's test was not significant, (if therefore the groups' variance was homogeneous), a 2 independent samples t-test it would be performed to test the differences of means between two different groups; it would otherwise have been performed a Welch's t-test for unequal variances. To test the differences of means between T0 and T1 for the experimental group the t-test for paired data was used. Instead, if the Levene's test was positive (P<0.05), i.e., the groups were not homogeneous, the t-test corrected for unequal variances by Welch test was performed.

Finally, Cronbach's alpha statistic was used to investigate the internal consistency of a questionnaire. The interclass correlation coefficient (r) was used to measure the reliability of questionnaire in our study.

All tests with p-value < 0.05 were considered significant. The statistical analysis was performed by Matlab statistical toolbox version 2008 (MathWorks, Natick, MA, USA).

Results

Sample description

Sixty students have recruited in the study during their training course, 26 males and 34 females, and their average age was 21 years. The participants had divided into experimental and control groups: 30 subjects for each group (Table 1). The Levene's test of the equality of variances showed that the hypothesis of the homogeneity of the variances yielded a value of F=2.01 (*p=0.161*). Thus, we proceeded with at-test to compare the continuous variables while for categorical variables we used chi-squared tests of the two samples.

Student's knowledge

The differences found between the scores at T0 in both groups regarding 'knowledge' of obtaining vascular access along with related management of the device and intravenous therapy (*t = 0.204, p = 0.838*) were not statistically significant. The differences found between the scores at T1 in both groups for obtaining 'knowledge' of vascular access, relative management of the device and intravenous therapy (*t = 3.52, p = 0.001*) were statistically significant (Table 2). Therefore, starting from similar theoretical and practical knowledge, the students who carried out a practical exercise immediately after the theoretical lesson showed a better learning of theoretical concepts as well.

Student's vascular access performance

The mean score of the first simulation of the insertion and management of both vascular accesses performance was 57.13 (SD±4.81) for the experimental group and 38.88 (SD±9.16) for the control group (*t=9.66, p=0.001*). At T1, the mean of the second score relating to the insertion and management of both vascular access and intravenous therapy was 62.11 (SD±3.21) for the experimental group and 44.38 (SD±7.89) for the control group (*t=11.40, p=0.001*) (Table 3). We can therefore observe how having carried out a practical simulation immediately after the end of the theoretical lesson and having repeated the same simulation, has favored the acquisition of these skills compared to control group.

Table 1. Sample characteristics.

Characteristics		**Experimental Group Mean ± SD**	**Control Group Mean ± SD**
AGE		21.2; ±2.37	21.1; ±1.99
		N (%)	*N (%)*
GENDER	*Male*	13 (43%)	14 (47%)
	Female	17 (57%)	16 (53%)

Note: SD = Standard Deviation

Table 2. Level of knowledge.

	Time 0		Time 1	
	Control Group (N. 30)**	Experimental Group (N. 30)**	Control Group (N. 30)**	Experimental Group (N. 30)**
Mean±St.Dev	58.5±21.49	57.3±23.89	85.66±15.68	68.06±22.48
Shapiro-Wilk test	W=0.987 *p*=0.445		W=0.878 *p*=0.625	
t-value (df)	0.204 (58)		3.52 (58)	
p value	0.838		*0.001	

Legend: N = number of participants

Table 3. Vascular access performance.

	T0		T1	
	Experimental Group (N. 30) **	Control Group (N. 30) **	Experimental Group (N. 30) **	Control Group (N. 30) **
Mean±St.Dev	57.13±4.81	38.88±9.16	62.11±3.21	44.38±7.89
Shapiro-Wilk test	W=0.950 *p*=0.692		W=0.768 *p*=0.545	
t-value (df)	9.66 (58)		11.40 (58)	
p value	*0.001		*0.001	

Legend: N = number of participants

Student's satisfaction

While not showing complete statistical significance, the satisfaction noted by the students during the clinical simulations improved as more of them were surveyed (Table 4). The results show an increase in the total average score and for each item in the experimental group. The latter group, which used a simulation as an integral part of their lesson, already showed better average scores on the first survey.

Discussion

Finding and managing vascular access and correctly administering intravenous therapies represent some of the essential practices of the nursing profession, regardless of the setting in which one operates (2, 32).

The literature does not present clear results in favor of a specific teaching method aimed at teaching the theoretical and practical skills necessary for the correct management of the entire process under study. Thus, further studies are recommended (2).

Our results showed that the levels of knowledge increased in the two groups following the simulation. Although not statistically significant, the mean score of the experimental group was slightly higher than that of the control group, even at T0. Furthermore, a significant increase in the mean score, with a reduction in the standard deviation, had noted within the experimental group. This indicates the importance of repeated simulations. As reported in the literature, simulation improves the retention of such knowledge (5, 33).

The results of our study showed that the experimental group immediately had better average scores in relation to the correct delivery of clinical services. Furthermore, the use of simulations produced increases in these scores in both groups. These results suggest that the use of simulators within the curricula of nurses is successful in transferring certain skills, as indicated by

Table 4. Student satisfaction.

	T0	T1	T1	EG (T0-T1)	EG vs CG (T1-T1)
SSE extension	**EG**	**EG**	**CG**	**p value**	**p value**
TOTAL (%)	1434 (79.6)	1497 (83.1)	1326 (73.6)	0.06	0.06
	mean (±SD)	*mean (±SD)*	*mean (±SD)*		
d.: debriefing and reflections	3.4 (0.7)	3.7 (0.689)	3.6 (0.58)	0.10	0.55
d.: clinical reasoning	3.8 (0.61)	3.9 (0.59)	4.1 (2.4)	0.52	0.23
d.: clinical skills	3.5 (0.3)	4 (0.7)	4.6 (0.75)	*0.001	*0.002

All data had normal distribution.
*Legend: SSE = Satisfaction Simulation Experience; d. = dimension (SSE); EG = Experimental Group; CG = Control Group; SD = Standard Deviation; TO = Time 0; T1 = Time 1; * = statistically significant*

the scientific literature (5). However, existing work emphasize that there is no distinction between the types of simulations used in the transfer of these skills (34).

Analysis of the SSE showed that the satisfaction perceived by the students was higher in the experimental group at T0 and increased with repeated use of the simulator. In fact, satisfaction with simulations, in addition to bolstering learning, (21) strengthens clinical knowledge (26).

Therefore, it appears clear that the use of simulators can play an important role in the training paths of nurses.

Our study has some limitations. First, the two groups were not homogeneous at the outset. Furthermore, in the four days between T0 and T1, we did not know with certainty whether any students implemented their own personal practices regarding the clinical skills of the procedure under study; just as we do not have the certainty that the procedure being studied may have already been taken into consideration by the students within their precedent clinical settings. Furthermore, although the checklists were drawn from the literature and the content validity of these forms was established, we did not assess the inter-rater reliability.

Conclusion

In sum, our results show how a training method that includes the use of simulators promotes the acquisition of knowledge and skills related to finding and managing vascular access while correctly managing intravenous therapy earlier than the classic training still in use today. Furthermore, the same results show how the repeated use of simulators leads to improved acquisition of these skills and greater satisfaction on the part of students. Simulation practices should therefore reproduce real situations as faithfully as possible and should be included in the teaching agenda of nursing education. However, further studies with larger, multicenter sample sizes are needed, as well as studies that make comparisons with areal clinical environment.

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