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ORIGINAL ARTICLE

The impact of simulation-based teaching on home hemodialysis patient training

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Abstract

Background: Simulation has been associated with positive educational benefits in the training of healthcare professionals. It is unknown whether the use of simulation to supplement patient training for home hemodialysis (HHD) will assist in improving a patient's transition to home. We aim to assess the impact of simulation training on home visits, retraining and technique failure.

Methods: Since February 2013, patients training for HHD are required to dialyze independently in a dedicated training room (innovation room) which simulates a patient's home prior to graduation from the program. We performed a single-center retrospective, observational, cohort study comparing patients who completed training using the innovation room ($n = 28$) versus historical control ($n = 21$). The outcome measures were number of home visits, retraining visits and technique failure.

Results: Groups were matched for age, gender, race, body mass index and comorbidities. Compared with controls, significantly more cases had a permanent vascular access at the commencement of training (57.1 versus 28.6%, χ^2 P = 0.04). Cases spent a median of 2 days [IQR (1.75)] in the innovation room. Training duration was not statistically different between groups {cases: median 10.0 weeks [IQR (6.0)] versus controls: 11.0 [IQR (4.0)]}. Compared with controls, cases showed a trend towards needing less home visits with no difference in the number of re-training session or technique failure.

Conclusions: Simulation-based teaching in NHHD training is associated with a trend to a reduction in the number of home visits but had no effect on the number of re-training sessions or proportion of patients with technique failure.

Key words: home hemodialysis, patient training, simulation teaching

Introduction

Nocturnal home hemodialysis (NHHD) is an intensive form of renal replacement therapy (RRT) wherein patients undergo hemodialysis (HD) treatment at home for 4–6 nights per week at 6–8 h per session. While studies support the numerous beneficial effects of NHHD over conventional HD (CHD) [1–4], widespread uptake of this dialysis modality has been limited by patient-related, social and organizational barriers. A cross-sectional survey of Canadian CHD patients identified fears relating to self-cannulation, perceived lack of efficacy in performing dialysis, burden on family members and fear of a catastrophic event while dialyzing at home as important barriers to the widespread adoption of NHHD [5]. Additionally, the inability to perform NHHD independently or with minimal

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assistance has been identified as one of the strongest predictors of poor outcome [6].

Effective patient education and training are crucial to overcoming some of the patient-perceived barriers to adopting NHHD and ensuring a smoother transition to home. Depending on the learner and the teaching objectives, home HD training usually employs a variety of teaching techniques which can include mini-lectures, use of training manual and other training aids such as videos, slide presentations and step-by-step pictorial representation of the dialysis process [7]. Patient training also engages hands-on techniques through demonstration and practice. In a qualitative study to explore patient experiences and perceptions while undergoing home HD training, the use of a variety of teaching methods was deemed as an effective means of learning [8].

Simulation-based teaching is a technique, rather than just technology, through which actual or probable real-life situations or systems are recreated in a fully interactive manner for the purpose of learning and practice [9]. Simulation is a well-established teaching strategy which has been used extensively in the training of airline pilots and stewards, military personnel, athletes and healthcare professionals including medical students. In healthcare, simulation-based teaching can take the form of screen-based (computer) simulation, virtual and simulated patients, static and simulated manikins and task trainers [10]. In nephrology, a Peritoneal Dialysis Simulator, Hemodialysis Practice Arm and full-sized manikin attached to a simulated dialysis machine have been used to train dialysis staff but have not been utilized in the education and training of home-dialysis patients. Growing interest in this teaching strategy stems from the opportunity to practice in a safe learning environment while promoting critical and evaluative thinking to reinforce subtleties in concepts. It also allows the learner to evaluate the effectiveness and witness the consequences of their actions.

The use of simulation-based teaching in the training of home HD patients has not been explored previously. We hypothesize that use of simulation-based teaching in NHHD patient training improves a patient's transition to home and increases the likelihood of successfully dialyzing independently. We aim to assess the impact of the use of the innovation room on the number of home visits and number of re-training sessions as well as technique survival.

Materials and methods

The innovation room

To adapt a simulation-based teaching technique in NHHD patient training, a dedicated home HD training room (innovation room) which simulates a patient's home was established at the Toronto General Hospital (Toronto, Ontario, Canada) in February 2013. This purpose-built training room which is located distant from the home HD training center is equipped with a bed, desk, television, en-suite toilet, dialysis machine, portable reverse osmosis machine as well as supplies required for self-cannulation. The only communication permitted between the training patient and the primary training nurse is via a phone. The physical distance between the innovation room and the in-hospital training facility allows for patients to dialyze independently, and away from their primary training nurse. Since February 2013, all patients completing NHHD training are required to attend the innovation room for several independent dialysis sessions prior to graduation from the program. Depending on a patient's performance in the innovation room, the primary training nurse determines a patient's readiness for home.

Study design and patient population

A single-center retrospective, observational, cohort study using chart review was performed from 31 July 2011 to 31 August 2014. Cases were identified as all NHHD trained patients at the Toronto General Hospital who attended the innovation room prior to graduation from 1 February 2013 to 31 August 2014. For comparison, we identified a historical cohort who completed training in a 19-month period prior to the inception of the innovation room (31 July 2011 to 31 January 2013). We excluded patients who withdrew prior to completion of training and those who have previously trained in home HD. Both cases and historical controls were trained by one of four experienced home HD training nurses using the Bellco Home Care System formula™ 2000 dialysis machine with prescribed blood flow rates of 300 mL/min and dialysis flow rates of 500 mL/min. Patients were prescribed to perform NHHD for 5 nights per week at 6–8 h per treatment session.

We collected data on patient demographics (age, gender, ethnicity), body habitus (body mass index) and clinical characteristics (cause of ESRD, ESRD vintage, vascular access and co-morbidities) at the commencement of training. We used a modified version of the Charlson Comorbidity Index (CCI) score to assess the burden of comorbidities [11].

Outcomes

The outcome measures were number of home visits, number of re-training sessions and technique failure which was defined as transfer to peritoneal dialysis, satellite or in-center HD. These endpoints were selected given that these are easily measured surrogates for a patient's ability to cope with dialyzing independently at home.

Statistical analysis

Statistical analyses were performed using SPSS, version 17.0 (Statistical Package for Social Sciences; SPSS Inc., Chicago, IL, USA). Data are presented as median and interquartile range for continuous variables to account for the skewed nature of the parameters given the small sample size. Categorical variables are presented as numbers and percentages. Between group comparisons were analyzed using the Mann–Whitney test while categorical variables were compared using chi-square (χ^2) or Fisher exact tests. Statistical significance was defined as $P < 0.05$.

Results

Patient characteristics

A total of 69 patients commenced training for NHHD during the study period between 31 July 2011 and 31 August 2014. Of these, 16 (24.3%) withdrew from the program prior to completion of training. Thirty patients attended the innovation room and we identified 23 historical controls for comparison. Two patients were withdrawn from each group in view of prior home-dialysis training (see Figure 1).

The baseline characteristics of both cases and controls are presented in Table 1. The groups were matched for age, gender and race distribution and body mass index. The most common reported causes of end-stage renal disease for the cases were glomerulonephritis (39.3%), followed by others (32.1%) then diabetes mellitus (14.3%). This distribution was not significantly different from the historical control. Compared with the controls, significantly more cases used a permanent access at the commencement of home-dialysis training (57.1 versus 28.6%, χ^2 $P = 0.04$). Dialysis vintage was greater for the cases [median 46.5

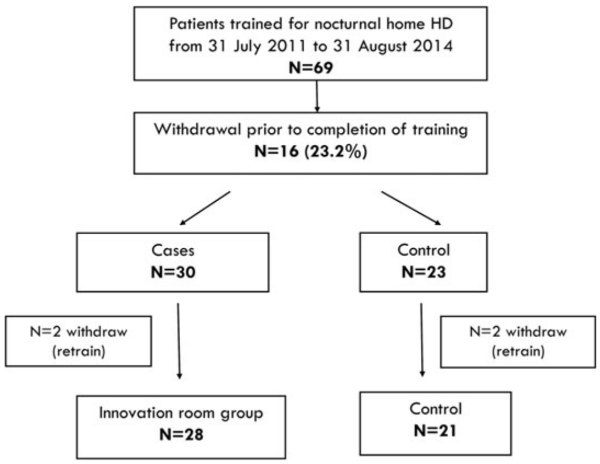

Fig. 1. Patient flow chart.

Table 1. Patient characteristics

	Case (*n* = 28)	Control (*n* = 21)	P-value
Age at training (years)	44.5 (17)	40.0 (32)	0.73
Males, *n* (%)	16 (57.1)	12 (57.1)	0.62
Race, *n* (%)			
Caucasian	9 (32.1)	9 (42.9)	0.43
Asian	8 (28.6)	3 (14.3)	
Black	4 (14.3)	3 (14.3)	
Indian subcontinent	6 (21.4)	4 (19.0)	
Mid-east/Arabian	1 (3.6)	0 (0)	
Latin American	0 (0)	2 (9.5)	
Body mass index (kg/m^2)	24.9 (13.0)	23.9 (6.8)	0.12
Cause of ESRD, *n* (%)			
Glomerulonephritis	11 (39.3)	5 (23.8)	0.48
Diabetes	4 (14.3)	4 (19.0)	
Hypertension	2 (7.1)	0 (0)	
Others	9 (32.1)	9 (42.9)	
Unknown	2 (7.1)	3 (14.3)	
Presence of permanent access during training (AVF or AVG), *n* (%)	16 (57.1)	6 (28.6)	0.04
Duration of RRT prior to home HD training (weeks)	46.5 (767.5)	4.1 (93.4)	0.28
Days in the Innovation Room (days)	2 (1.75)	—	—
Duration of follow-up (months)	12.1 (10.5)	9.4 (9.9)	0.93
Training duration (weeks)	10.0 (6.0)	11.0 (4.0)	0.15

Data presented as median (IQR) and comparison by Mann–Whitney for continuous variables. For categorical variables, data is presented as numbers (percentage) and comparison by Chi-squared or Fisher exact test.
AVF, arteriovenous fistula; AVG, arteriovenous graft; RRT, renal replacement therapy.

weeks IQR (767.5)] compared with controls [median 4.1 weeks IQR (93.4)] although this was not statistically significant (P = 0.28).

The patient comorbidities and social characteristics are presented in Table 2. The groups were not significantly different with regard to the presence of diabetes, coronary heart disease, chronic obstructive airways disease and CCI score. There was trend to a difference in smoking status between groups (P = 0.80). The groups were similar with regard to proportion of patients living alone (case 10.7 versus control 9.5%), presence of training partner (case 17.9 versus control 14.3%), proportion owning their own home (case 89.3 versus control 81.0%) and proportion unemployed (case 50.0 versus control 42.9%).

Table 2. Patient comorbidities and social situations

	Case (*n* = 28)	Control (*n* = 21)	P-value
Presence of diabetes, *n* (%)	8 (28.6)	6 (28.6.0)	0.62
Presence of CHD, *n* (%)	1 (3.6)	3 (14.3)	0.20
Presence of COAD, *n* (%)	1 (3.6)	1 (4.8)	0.70
Previous renal transplant, *n* (%)	10 (35.7)	6 (25.0)	0.30
Smoking status, *n* (%)			
Never smoked	24 (85.7)	15 (71.4)	0.08
Ex-smoker	2 (7.1)	6 (28.6)	
Current smoker	2 (7.1)	0 (0)	
Charlson Comorbidity index	3.0 (3.0)	3.0 (3.5)	0.80
Present with training partner, *n* (%)	5 (17.9)	3 (14.3)	0.53
Percent with own home, *n* (%)	25 (89.3)	17 (81.0)	0.34
Percent unemployed, *n* (%)	14 (50.0)	9 (42.9)	0.42
Percent home alone, *n* (%)	3 (10.7)	2 (9.5)	0.64

Data presented as median (IQR) and comparison by Mann–Whitney for continuous variables. For categorical variables, data is presented as numbers (percentage) and comparison by Chi-squared or Fisher exact test.
CHD, coronary heart disease; COAD, chronic obstructive airways disease.

Table 3. Effect of exposure to the innovation room on outcomes

	Case (*n* = 28)	Control (*n* = 21)	P-value
Number of home visits (*n*)	1.0 (1.0)	2.0 (2.0)	0.058
Number of retraining sessions (*n*)	0.0 (1.8)	0.0 (4.5)	0.84
Proportion with technique failure, *n* (%)	0 (0)	1 (3.6)	0.54

Data presented as median (IQR) and comparison by Mann–Whitney for continuous variables. For categorical variables, data is presented as numbers (percentage) and comparison by Chi-squared or Fisher exact test.

Table 4. Effect of the presence of permanent access on outcomes

Use of permanent access	Yes (*n* = 22)	No (*n* = 27)	P-value
Training duration (weeks)	11.5 (5.0)	10.0 (4.0)	0.26
Number of home visits (*n*)	1.5 (1.25)	1.0 (1.0)	0.78
Number of retraining sessions (*n*)	0.0 (1.25)	0.0 (3.0)	0.55

Data presented as median (IQR) and comparison by Mann–Whitney for continuous variables. For categorical variables, data is presented as numbers (percentage) and comparison by Chi-squared or Fisher exact test.

Outcomes

The cases spent a median of 2 days [IQR (1.75)] in the innovation room. The duration of follow-up for this study was not statistically significant between groups with a median follow-up of 12.1 months [IQR (10.5)] for the cases and 9.4 months [IQR (9.9)] for the controls. Furthermore, the training duration was not statistically different {cases: median 10.0 weeks [IQR (6.0)] versus controls 11.0 [IQR (4.0)]}.

Compared with controls, the cases showed a trend towards needing less home visits but there was no difference in the number of re-training sessions or proportion of patients with technique failure (see Table 3). The presence of a permanent access during training had no significant impact on training duration, number of home visits or number of retraining sessions (Table 4).

Discussion

To our knowledge, this is the first study to assess the feasibility and utility of simulation-based teaching as a supplement to traditional teaching methods in the training of patient for NHHD. We report that simulation-based teaching using the innovation room in NHHD patient training is associated with a trend to a reduction in the number of home visits but had no effect on retraining sessions or technique failure. The training duration was not significantly prolonged.

Simulation-based teaching is an education tool based on the fundamentals of active and adult-learning theories which focuses on learning by doing, thinking about and assimilation of lessons learned into everyday behavior [12]. This process of deliberate practice highlights gaps in knowledge or skills, encourages attention, concentration and repetition of skills until the process becomes second nature [13, 14]. Simulation-based medical education has been shown in a quantitative meta-analysis to be superior to traditional clinical education in specific medical procedural skill acquisition [15, 16]. While simulation-based teaching has not been previously assessed in home HD patient training, use of adult-learning theory-based training curriculum in peritoneal dialysis training has been shown to positively affect outcomes [17].

The present study represents our pilot attempt to quantify the clinical impact of simulation-based teaching in home-dialysis training from a patient perspective. We chose home visit, retraining visits and technique failure as outcome measures since these where thought to best approximate whether patients achieved their training objectives and can comfortably transition to dialyzing independently at home. We report a trend to decreased need for home visits following exposure to the innovation room suggesting increased confidence in performing the task at home and need for less support. While home visits provide an ideal way for the dialysis team to assess for adequacy of training and observe a patient's adherence to the dialysis protocol, home visits also come at a price mainly from cost related to nursing time. The lack of effect on retraining session and technique survival may not be entirely surprising. Often, there are other factors which could contribute to these outcomes that are not directly influenced by simulation training such as vascular access complications. Lastly, while our analysis did not report an association between type of vascular access used at the start of training and study outcomes, we cannot dismiss the possibility that differences in vascular access between groups could still have influenced the study results.

This study has several important limitations. Given the retrospective, observational and cohort study design, causality cannot be inferred. As data collection was dependent on chart review, the presence of information bias cannot be excluded. There is also limitation relating to dependence on data that is already collected by different individuals principally for clinical rather than research purposes. There is a potential for misclassification bias if individuals in the innovation room group (cases) were allowed to refuse to attend. We are unable to account for the presence of unknown confounders which may have an important impact on the outcomes of interest. Rather than a lack of effect of simulation training, these inherent differences in patient characteristics could partly explain the lack of effectiveness of simulation training on study outcomes. With the use of a historical control, one cannot exclude an era effect with observed difference in the two groups potentially explained by other changes to training practice during the two study periods rather than exposure to the innovation room. Lastly, we cannot exclude a period effect given that the risk of need for home visit and re-training changes with time. We attempted to limit this by ensuring that the duration of follow-up was similar between the two groups.

Conclusion

This study has shown that simulation-based teaching in patients training for home HD may provide an important supplement to traditional teaching strategies in preparing patients as they transition to the home environment. A prospective randomized controlled study with a larger sample size will be required to confirm the beneficial impact of this teaching strategy on patient training. Whether simulation-based teaching has additional benefits on qualitative measures such as self-confidence, preparedness for independent dialysis, knowledge acquisition, clinical reasoning and facilitate reassessment of patient technique and adherence to the dialysis process will require further study.

Conflicts of interest statement

None declared.

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