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Simulation-based learning compared with conventional methods in procedural skill



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ABSTRACT

Background: Recently in the development of the technology, the handling, and management taken for patients are increasingly complex and diverse, especially in the field of cardiology intervention. There are various interventions that residents need to know and cleanse in the field of cardiology in fulfilling their competencies before becoming cardiologists. If the intervention is not done properly, it can affect the patient safety risk or other undesirable complications of the patient. Conventional learning as one of the learning methods always seems to be used in several learning topics. In the middle of resident's hectic schedule and the competencies that must be mastered by them, it triggered the emergence of new learning methods in cardiology, especially in the field of intervention. Simulation-based learning (SBL) has a role in cardiology medicine. Thus, the present review aims to describe the conventional learning, SBL and develop a more effective method in the learning process of cardiology resident procedural skill.

Method: We searched for all articles using the term "SBL in interventional cardiology, the effectiveness of SBL for cardiology resident skill, conventional learning method in cardiology medicine, SBL vs. conventional method in cardiology medicine, SBL vs. conventional method in interventional cardiology" in the title or research abstract. We did search on Google Scholar, Medical Education Journals, and Cochrane from 2004 until 2019. We also take a similar topic from the citation of the journal that included in this review.

Conclusion: The effectiveness of SBL compared with conventional learning method is better in improving procedural cardiology resident skills. Given the increasing demand for procedural capability competencies that must be possessed by resident cardiology, some benefit of that learning method can be achieved from SBL especially in terms of procedural skills and patient safety.

Keywords: simulation, learning, skill, impact

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INTRODUCTION

Specialist education for the doctor, i.e., residency is one of the levels of education in sustainable health sciences.¹ Residency education not only requires abilities in cognitive but also clinical skills in dealing with patients. The resident must also be able to manage the time between the learning process, handling patients and limiting working hours both in the hospital and outside the hospital. The existence of restrictions on working hours is related to the assumption that the patient's outcomes will reduce if the procedure is carried out by residents and had risks to patient safety.² As mentioned by The Institute of Medicine, it states that around 100,000 patients are died annually from preventable mistakes in hospitals, with an additional approximately 1 million people who were injured.³ These factors can reduce resident exposure to practical procedures so that they weaken the skills and experience of the intervention actions of prospective cardiology specialists.

On the other hand, as technology develops, the management taken for patients are also increasingly complex. The intervention was also familiar with handling patients in the medical world, especially in the field of cardiology. There are various interventions that residents need to know and cleanse in the field of cardiology in fulfilling their competencies before becoming cardiologists, such as coronary angiography, endovascular procedure, percutaneous coronary intervention, etc.⁴ If the intervention is not done properly, it can affect the patient safety risk or other undesirable complications of the patient.

Until now we still encounter conventional learning methods in the field of cardiology intervention, where residents are taught about intervention procedures by being tutored by interventional cardiologists. This method has several disadvantages such as involving patients in early learning, especially in cardiology intervention actions.⁵ The British Cardiovascular Society recently stated the role of SBL in cardiology. The

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simulation is in the form of a technique for replacing or amplifying real experiences with interactive settings including patient simulation, role play, virtual reality tools, etc. SBL is one of the safest and controlled educational methods that can be applied to many other disciplines without providing an additional risk to patient safety.⁶

This SBL has many roles and is applied in other aviation, military and other professions.⁷ Along with the development of technology, the enthusiasm for training with simulations has been increasing lately.⁸ With the advancement of technology, simulation training provides opportunities to be more realistic with the situation of actions/interventions in the field. Unfortunately, the role of SBL in the field of cardiology especially for cardiology interventions is still rarely discussed and raised into research, and until now there have been no studies that discuss the positive effects of simulation training on patient outcomes. Methods of training and learning for residents related to interventions in handling patients need to be carried out while considering patient safety. This SBL is expected to be a resident's cognitive and skill training method in the concept of medical education in the future.

METHODS

In this paper, we will describe the conventional learning, SBL and summarise a method which is more effective in the learning process of cardiology resident procedural skill. We searched for all articles or research on Google Scholar, Medical Education Journals, and Cochrane using the term “SBL in interventional cardiology, the effectiveness of SBL for cardiology resident skill, conventional learning method in cardiology medicine, SBL vs. conventional method in cardiology medicine, SBL vs. conventional method in interventional cardiology” in the title or research abstract. We also take a similar topic from the citation of the journal that included in this review. The inclusion criteria were: (1) articles which were published in 2004 until 2019, (2) articles that reported the effectiveness of SBL methods or conventional method in the procedural skill of cardiology resident, (3) the participants of the studies were cardiology fellow or cardiology resident. The keywords used were SBL, conventional learning method, traditional learning method, teacher-centered learning, procedural skill, cardiology resident, interventional cardiology.

RESULTS

Conventional Learning Methodologies in Cardiology

While discussing education especially in the field of medicine, conventional learning is also known as teacher-centered learning (TCL). This method has been applied for a long time in the education system. But in this development era, the TCL method seems no longer compatible with what is needed by the postgraduate students, especially in the medical field. That is the reason why Abraham Flexner, one of the leaders in medical education who proposes a new learning system that is better in medical education. Conventional learning is considered boring because learning only goes one direction, namely from their teacher.⁹ The learning method also seems to be incompatible with the development of the times, considering that there are now more and more recent procedural methods with increasingly advanced technologies. Nevertheless, until now, this learning method is still seen in the field of health, especially in the study of cardiology medicine.

Conventional or traditional learning methods of clinical medical education especially in cardiology medicine refer to the Halstedian “see one, do one, teach one” approach.^{3,10} As in cardiology medicine, until now, that method is still used for the cardiology residents who are exposed to cardiology procedures under the tutelage of an experienced physician.

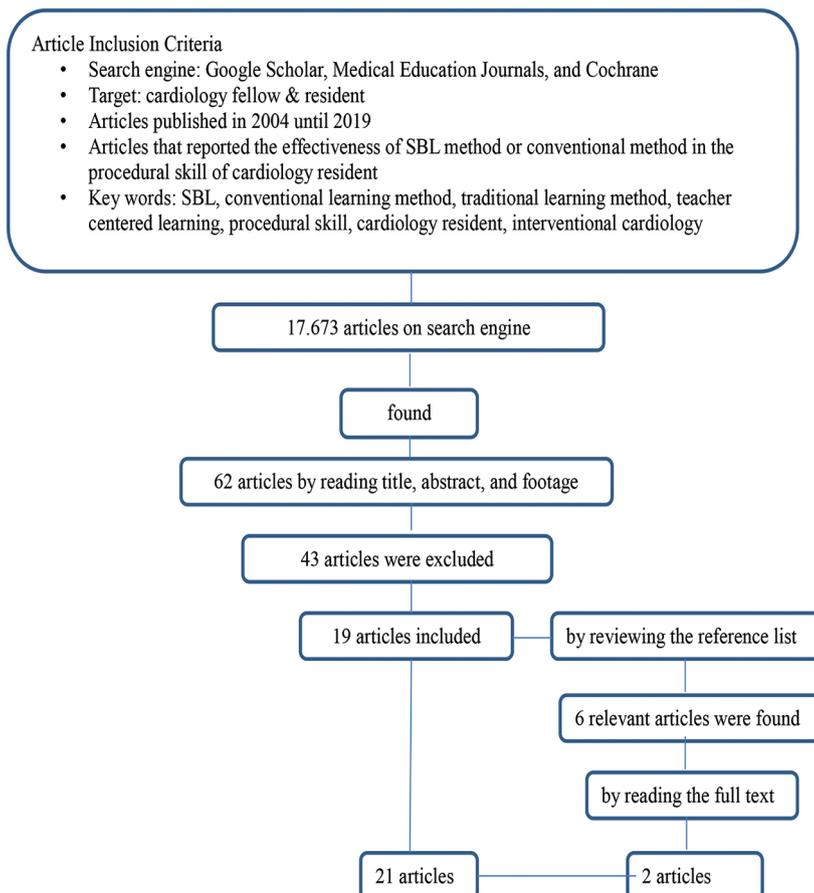


Figure 1. Study or articles selection process

These methodologies offer short implementation chain for the residents to learn something. Conventional learning included detailed lesson given by the tutor to the residents.¹¹ After that, the residents can participate in the procedure on a real patient under the guidance of the tutor who intervenes only if mandatory. It allowed the resident an opportunity to experience the procedure on the real patient even though they had just learned it. That condition has some disadvantages. The most important concern is on the patient safety aspect because it involves exposing patients to residents in their early learning phase. After mastering the procedure, the resident becomes the teacher and the cycle repeats.

It isn't easy to find literature that discussed conventional learning. Very few recent studies have evaluated the conventional learning method specifically related to the field of interventional cardiology. One study from Ponti et al.¹¹ evaluated conventional training method in the performance of transseptal catheterization. Based on their study, the training time of the fellows on the conventional training group was significantly longer, had lower post-training performance scores than the simulator group and also a high number of recurrent errors.¹¹ Another research from Macgaghie et al.¹² also stated that in this many complex procedural actions, the conventional learning method is inferior to another method (i.e., simulation learning) in achieving clinical skill, especially in cardiology medicine.¹² From these two studies, it seems that the use of conventional learning methods has lessened in cardiology education.

SBL in Cardiology

Many cardiology interventions are complex, with many steps of the procedures and need to be learned in an authentic environment. There is widespread acceptance of simulation as a training modality across many medical and surgical specialties including in cardiology medicine to ensuring the patient's safety. It is known that simulation is derived from the Latin word "simulare" which means 'to copy'.¹³ It has been defined as a technique to replace or amplify real experiences with guided experiences to study something that is possible in real life. The simulation includes simulated patients, role play, virtual reality devices, electronic manikins and many more. Simulation has been one of the medical training since 400 years ago, and in cardiology medicine itself, this method began to develop since 2000.⁶

The British Cardiovascular Society recently published a report on the role of SBL in cardiology. It is stated that SBL has some benefits include

immediate feedback, the learning process without exposing the patient to risk, an opportunity for training management of potential complications, and it can be adapted to the learner in a flexible way.⁶ Residents usually had high use of simulation early in their residency programs. The SBL helps cardiology residents to study coronary intervention, electrophysiology, and echocardiography with the help of technological advances such as simulators.¹⁴

The resident learning method that focuses on the skill to manage patients included non-invasive and invasive cardiology based simulation. The non-invasive cardiology based simulation consists of cardiac auscultation skill training with simulators, multimedia simulation, i.e., virtual patient encounters (VPE), cardiopulmonary resuscitation with a mannequin, and simulation-based echocardiography training.^{14,15} All of those non-invasive cardiology skills are important for the residents to diagnose, evaluate and manage all patients specifically those with known cardiac disease.

Moreover, the residents also need to achieve the necessary clinical skill of some invasive procedures. The interventional procedure in cardiology places high demands on the cognitive and psychomotor skill of the operator without giving risk to the patient. It is known that SBL has the potential to fulfill these needs. There are several studies which stated that SBL has a role in interventional cardiology. According to the research of Voelker et al.¹⁶, with eighteen cardiology residents from Germany included in the research stated that curriculum-based mentored virtual reality (VR) simulation training improves the performances level of cardiology residents in coronary intervention.¹⁶ The same result from Ponti et al.¹¹ study, which compared the performance of electrophysiology fellows stated that transseptal catheterization with virtual reality results in shorter training and superior post-training performance of cardiology fellows.¹¹ Another interventional study from Farooq et al.¹⁷ who had their general cardiology fellows to participate in the study found that simulation training program could improve cardiology fellows and resident preparedness, confidence, and patient safety in the catheterization lab.¹⁷ Besides that, on the meta-analytic study from Macgaghie et al.¹², based on the 14 studies evaluating the comparative effectiveness of simulation training compared to traditional method found that simulation training with deliberate practice is superior to traditional clinical medical education in achieving clinical skill goals.¹² Those studies showed that SBL has been used in the invasive procedure and had some role in the improvement of skill acquisition, service efficiency, and upstream the patient safety.

DISCUSSION

SBL vs. Conventional Learning Method: Which One Better for the Procedural Skill of Cardiology Resident?

From the search for evidence that we have done, few studies discuss conventional learning in interventional cardiology medicine. The average study of conventional learning also examines the latest learning methods that are considered more in line with the development of current science and technology. A comparative study from Ponti et al.¹¹ evaluates simulator-based training and conventional training methodologies for the performance of transseptal catheterization in fourteen electrophysiology fellows.¹¹ The fellows with no exposure to transseptal catheterization were randomized to the 2 different training modalities. At the end of the training with 2 different methods, each fellow needed to carry out transseptal catheterization and served as the primary operator in the procedure for 3 consecutive patients. The performance score for the procedure performed will be assessed by the supervisor.

The authors report training time of the fellows on the conventional training group was significantly longer, had lower post training performances scores than the simulator group and also a high number of recurrent errors.¹¹ On conventional groups, seven fellows make repeated mistakes, while in the simulator-based training group only 3 people make procedural errors. This shows that fellows in the simulation group understand more about step catheterization because training with virtual reality simulators provides more tangible procedural situations such as those in patients. Moreover, in the simulation groups, the fellows also have a high number of exposure to the procedure compared to the conventional training group. Not surprisingly, the simulator-based training group produced the shorter training times and superior post-training performance of the fellow in conducting transseptal catheterization.

The conventional learning included detailed lesson given by the tutor to the trainees (residents and fellows). The process of learning usually only goes one direction from their teacher.⁹ Although conventional learning has been one of the essential learning methods in education, it also seems to be incompatible with the development of the times, considering that there are now more and more recent procedural methods with increasingly advanced technologies.

Another meta-analytic comparative study from Macgaghie et al.¹² also shows that the conventional learning method is less compatible to be applied in the learning process.¹² They identified 14

studies which met the inclusion criteria from 3742 articles. The study evaluated the comparison of the effectiveness of traditional clinical education with simulation-based medical education (SBME) on the skill acquisition goals. The study lasted quite a long time, from 1999 to 2010 and found that SMBE with deliberate practice was superior to traditional clinical education in fulfilling the acquisition skills.

Some evidence shows that the SBL has a role in the graduate medical education program specifically for the cardiology resident and cardiology fellow. Two studies were investigating simulation training and transfer of skills to cardiac interventional procedures.^{16,18} One prospective study from Voelker et al.¹⁶ evaluated the role of simulation-based training in improving the procedural skills of coronary intervention from 18 cardiology fellows.¹⁶ Each of the 9 fellows was randomly assigned to the simulation group or the control group. In the simulation group, 9 fellows received 7.5 hours of virtual reality (VR) simulation training, while 9 other people in the control group received 4.5 hours of lectures before carrying out the interventional coronary procedure. Each fellow will be evaluated for their performance with a skill score by 3 interventionalist experts, who do not know whether the fellow enters the simulation or control group. The author found that curriculum-based mentored VR simulation training can raise the performance level of cardiology fellow in doing the coronary intervention. The simulation training is said to not only provide immediate feedback on fellow performance but also teach procedure steps in more detail, analysis and interpretation of cases more clearly as seen in the real patient. Similar results were also found by Schimmel et al.¹⁸ who examined the effect of SBME on the skill to perform coronary angiography.¹⁸ The study was conducted from January 2013 to June 2013 involving 14 cardiovascular fellows. All fellows can get the didactic teaching and preceptor-lead training on the endovascular simulator. The result says that SBME significantly can improve coronary angiography skill of the cardiovascular fellows. The marked improvement in technical skills to perform coronary angiography is encouraging, although the authors do not report which skills drive the significant improvement.

Another two studies stated that simulation learning acts in the increasing of skill trainees, especially the cardiology resident.^{19,20} Based on Bagai et al.¹⁹ study who evaluate the procedural skill of 12 cardiology residents in a group with virtual reality simulator and 15 cardiology residents without simulator training on cardiac catheterization.¹⁹ From this prospective randomized controlled pilot

study, the result is simulation learning with cardiac catheterization simulator is related to the skill of cardiology residents. This learning method also helps the resident had significant improvement in their technical procedural performance.

The next studies demonstrate the simulation learning gave benefit to the cardiology resident. Nelson et al.²⁰ do the 1-day course endovascular simulation training for cardiology, interventional radiology, and vascular surgery resident.²⁰ Although the research was conducted at different specialties, the results of his research showed positive feedback with all residents agreeing that the course in simulation training gave benefit in knowledge and skills.

All of that studies demonstrate some benefit to trainees (cardiology resident and fellow), however not all of the evidence or study in cardiology is positive. A cohort study from Jensen et al.²¹ provides another direct assessment of the transfer of skills from a simulator to cardiac catheterization.²¹ The research uses 54 residents who began training during the study period. Those residents were enrolled in a two-day course with 6 hours of simulator training that is watched over by a supervisor and 6 hours lectures. Surprisingly, the residents from the simulator course appeared to perform less well than the control group. The resident who is undergoing the course seems to have a higher rate of vascular complications. This condition indicates there is a potential negative consequence of some simulation training. It does not rule out the possibility of the differences in the results of the study compared to other studies due to confounding factors of several variables in the study.

Given the increasing demand for procedural capability competencies that must be possessed by resident cardiology, some benefit of that learning method can be achieved from simulation-based training, especially in terms of procedural skills and patient safety. From the studies above, we can also see that the effectiveness of SBL compared with conventional learning methods is better in improving procedural cardiology resident skills. Although only a few studies have discussed the topic, further studies need to be conducted that focus the benefits of simulation-based learning on resident readiness in carrying out procedural cardiology interventions as well as the effectiveness of SBL on patient outcomes.

In the future, SBL needs to be incorporated into a structured curriculum and not only as a one-time training in a particular session. SBL should be accompanied by other learning methods to maximize resident learning especially in the field of cardiology intervention. Simulation learning is

best done in environments and cases that are close to procedural reality, guided by interventionalist, accompanied by high fidelity simulation tools/simulators. With access to a simulator that is varied and requires a large investment cost, careful planning of deficiencies, institutional potential, and application in the field of this method into the resident cardiology learning system is needed.

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AVAILABILITY OF DATA AND MATERIALS

Data sharing is not applicable to this article as no datasets were generated or analysed during the study.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable to this review of published works.

CONSENT FOR PUBLICATION

Not applicable to this review of published works.

COMPETING INTERESTS

The authors declare that they have no competing interests.

REFERENCES

1. Vallurupalli S, Paydak H, Agarwal SK, Agrawal M, Kottner CA. Wearable Technology to Improve Education and Patient Outcomes in A Cardiology Fellowship Program – a feasibility study. *Health Technol.* 2013;3:267-270.
2. Joshi A, Wragg A. Simulation Training in Interventional Cardiology. *Interventional Cardiology Review.* 2016;11(1):70-3.
3. Westerdahl DE. The Necessity of High-Fidelity Simulation in Cardiology Training Programs. *Journal of the American College of Cardiology.* 2016;67(11):1375-7.
4. Gosai J, Purva M, Gunn J. Simulation in Cardiology: State of the Art. *European Heart Journal.* 2015:3-5.
5. Gallagher AG, Cates CU. Virtual Reality Training for the Operating Room and Cardiac Catheterization Laboratory. *Lancet.* 2004;364:1538-1540.
6. Fox K, Bradbury K, Curran I, Gammage M, Gray H, Holmberg B, Iqbal J, McNab D, Mills P, Nolan J. Working Group Report on Simulation-Based Learning 2011. *British: British Cardiovascular Society;* 2011.
7. Jones F, Neto CEP, Braghiroli OFM. Simulation in Medical Education: Brief History and Methodology. *Principles and Practice of Clinical Research (PPCR).* 2015;1(2):56-62.
8. Narang A, Velagapudi P, Rajagopalan B, LeBude B, Kithcart AP, Snipelisky D, Sinha SS. A New Educational Framework to Improve Lifelong Learning for Cardiologist. *Journal of the American College of Cardiology (JACC).* 2018;71(4):454-461.

9. Rukmini E, Cindy, Tanoto P. Student-Centered Learning in Relation to Class Performances and Soft Skills: A Meta-Analysis and Systematic Review. *The Indonesian Journal of Medical Education*. 2018;7(2):93-104.
10. Fox KF. Simulation-Based Learning in Cardiovascular Medicine: Benefits for the Trainee, the Trained and the Patient. *Heart*. 2012;98(7):527-28.
11. Ponti RD, Marazzi R, Ghiringhelli S, Uriarte JAS, Calkins H, Cheng A. Superiority of Simulator-Based Training Compared With Conventional Training Methodologies in the Performance of Transseptal Catheterization. *Journal of the American College of Cardiology (JACC)*. 2011; 58(4):359-363.
12. Mcgaghie WC, Issenberg SB, Cohen ER, Barsuk JH, Wayne DB. Does Simulation-Based Medical Education with Deliberate Practice Yield Better Results than Traditional Clinical Education? A Meta-Analytic Comparative Review of the Evidence. *Acad Med*. 2011;86(6):706-711.
13. Krishnan DG, Keloth AV, Ubedulla S. Pros and Cons of Simulation in Medical Education: A Review. *International Journal of Medical and Health Research*. 2017;3(6):84-7.
14. Harrison CM, Gosai JN. Simulation-Based Training for Cardiology Procedures: Are We Any Further Forward in Evidencing Real World Benefits?. *Trends Cardiovasc Med*. 2017;27(3):163-170.
15. McKinney J, Scalese RJ, Hatala R. Simulation in Non-invasive Cardiology. In: Levine AI, DeMaria S, Schwartz AD, Sim A, editors. *The Comprehensive Textbook of Healthcare Simulation*. 1st ed. London: Springer; 2013. p. 289-297.
16. Voelker W, Petri N, Tonissen C, Stork S, Birkemeyer R, Kaiser E, Oberhoff M. Does Simulation-Based Training Improve Procedural Skills of Beginners in Interventional Cardiology?-A Stratified Randomized Study. *J Interv Cardiol*. 2016;29:75-82
17. Farooq I, Guzman L. Cardiac Catheterization Simulation-Based Training for General Cardiology Fellows: A Single Center Experience. *JACC*. 2018;71(11):2657.
18. Schimmel DR, Sweis R, Cohen ER, Davidson C, Wayne DB. Targeting Clinical Outcomes: Endovascular Simulation Improves Diagnostic Coronary Angiography Skills. *Catheterization and Cardiovascular Interventions*. 2016;87:383-7.
19. Bagai A, Brien SO, Lawati HA, Goyal P, Ball W, Grantcharov T, Fam N. Mentored Simulation Training Improves Procedural Skills in Cardiac Catheterization. *Circ Cardiovasc Interv*. 2012;5:672-9.
20. Nelson K, Bagnall A, Nesbitt C, Davey P, Mafeld S. Developing Cross-Specialty Endovascular Simulation Training. *The Clinical Teacher*. 2014;11:411-5.
21. Jensen UJ, Jensen J, Olivecrona G, Ahlberg G, Lagerquist B, Tornvall P. The Role of A Simulator-Based Course in Coronary Angiography on Performance in Real Life Cath Lab. *BMC Medical Education*. 2014;14(49):1-7.



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