MANIKIN-TYPE TRAINING SIMULATOR MODEL FOR TRANSPEDICULAR PUNCTURE IN PERCUTANEOUS VERTEBROPLASTY*

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Abstract **OBJECTIVE: To develop and test a model of the human lumbar vertebra for training transpedicular puncture in percutaneous vertebroplasty. MATERIALS AND METHODS: Thirty lumbar vertebra models were constructed from methacrylate, plaster and ethyl-vinyl-acetate, using a rubber mold of human vertebrae. The intervertebral discs were made of silicone to provide anatomical similarity and fusion of five vertebrae. This model of spinal column segment was positioned within a manikin with an ethyl-vinyl-acetate lining so that direct visualization was not possible. A theoretical course was given to six trainees in radiology and neuroradiology who have tested the models with respect to parameters of similarity with the reality, performing 30 transpedicular punctures in three series of ten punctures a day, with one-week interval between the series. RESULTS: Each student performed 30 transpedicular punctures; however, eight of these punctures were disregarded because of manufacturing defects of the dummies observed during the procedures. Similarity data forms were filled in by all of the trainees following the procedures, with 100% of positive answers as regards the models similarity with the human body. CONCLUSION: It was possible to develop a training model for transpedicular puncture with a satisfactory degree of similarity with the human body, constituting an appropriate tool for training in vertebroplasty.**
Keywords: Spine; Puncture; Learning; Manikin; Vertebroplasty.

Resumo *Modelo simulador para treinamento de punção transpedicular em vertebroplastia percutânea.*
OBJETIVO: Desenvolver e testar a similaridade de modelo de coluna lombar tipo manequim para treinamento de punção transpedicular em vertebroplastia percutânea. MATERIAIS E MÉTODOS: Foram confeccionadas 30 vértebras lombares à base, principalmente, de metacrilato, gesso e etil-vinil-acetato, a partir de molde de borracha baseado em vértebra humana. Os discos intervertebrais foram feitos com silicone para que houvesse similaridade anatômica e fusão de cinco vértebras. O segmento da coluna foi acondicionado no interior de um manequim coberto por tela de etil-vinil-acetato para que não fosse possível a visualização direta. Foi realizado curso teórico para seis especializandos de radiologia e neurorradiologia, que testaram o modelo para vários parâmetros de similaridade com a realidade, realizando 30 punções transpediculares, em três sessões de dez procedimentos por dia, com intervalo de uma semana entre cada sessão. RESULTADOS: Cada aluno realizou 30 punções transpediculares, porém oito punções foram desconsideradas, pois se observaram problemas de manufatura dos modelos durante estes procedimentos. Após a realização das punções, todos os participantes preencheram o formulário de similaridade, com 100% de respostas positivas em relação à similaridade do modelo. CONCLUSÃO: Foi possível o desenvolvimento de modelo para punção transpedicular com similaridade satisfatória com o ser humano, configurando um instrumento de treinamento de vertebroplastia.
Unitermos: Coluna vertebral; Punção espinhal; Aprendizagem; Modelos anatômicos; Vertebroplastia.

INTRODUCTION

Percutaneous vertebroplasty is a radiological procedure involving puncture and injection of acrylic cement into a vertebral body[(1)]. This procedure is indicated in cases of fractures resulting from osteoporosis, malignant hemangiomas and metastases[(1,2)]. Current studies report analgesia[(3)], improvement in movements amplitude[(3,4)] and strengthening of the bone matrix[(1)], after the procedure.

Percutaneous vertebroplasty is included in the therapeutic arsenal for several specialties among which interventional radiology[(5)].

Aiming at medical professionals qualifying, workshops[(6,7)] provide them with theoretical knowledge and practical training. For the purposes of this teaching model, simulator models constitute invaluable tools to improve the medical trainees skills and confidence in complex and risky

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procedures, to keep the abilities acquired through simulated exercises even when therapeutic procedures are not being performed, and, finally, to provide a research field[8].

In the present study, the authors propose the development and evaluation of a manikin-type training model for transpedicular puncture in percutaneous vertebroplasty.

MATERIALS AND METHODS

Simulator

Vertebral segments were developed with molds of human lumbar vertebrae filled with a methacrylate and plaster (Figure 1A). The pulpy nucleus in the core of each vertebral body was simulated by a piece of sponge soaked with a methacrylate solution. Then, five of these vertebrae were grouped, constituting the lumbar segment of a spinal column. Disc spaces were filled with fragments of sponge soaked with a solution of polydimethylsiloxane and silica, imitating intervertebral discs (Figure 1B).

The necessary vertebral bodies alignment was kept by means of strips of ethylene vinyl acetate inserted between spinal processes, and articular facets were stuck together with a paste made of polydimethylsiloxane and silica.

The next step consisted of reproducing a human trunk, with a commercial plastic manikin called shell, with a wide lumbar-dorsal opening allowing the access to the inside of the shell. A wooden support was fixed into the shell with pressure screws and nuts. Two 2 cm-thick strips of ethylene vinyl acetate with 30 cm in length and height ranging between 4 cm at the middle third and 5 cm at the ends were fixed on the support. This structure allowed a stable positioning of the spinal column in a lordotic position on the wooden support (Figure 1C).

Finally, the access to the inside of the shell was limited by a coat of ethylene vinyl acetate, fixed to the border of the shell (Figure 1D), representing the skin.

Procedure

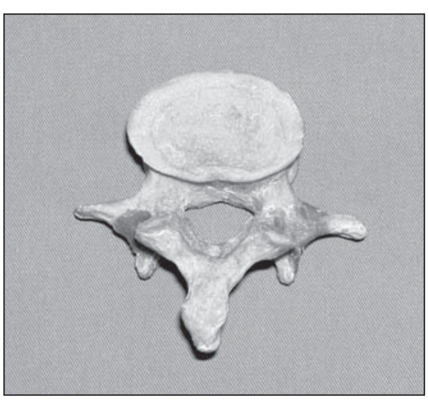
Each trainee should perform 30 transpedicular punctures in three series of ten punctures each, with one-week interval between series. The procedure was performed under fluoroscopy in a Philips Integris V5000 angiograph, with a Gallini®13-gauge needle for percutaneous vertebroplasty, in compliance with the technique described by Cotten et al.[1] (Figure 2A). Any construction failure detected during the procedures would determine the exclusion of such procedure for the effects of the learning curve results.

At the end of each training session, a methacrylate solution was applied to occlude the puncture pathway, allowing a new utilization of the vertebra model, up to three reutilizations.

The procedures were recorded on CDs and radiographic films (Figures 2B and 2C).

Model evaluation

The training model was evaluated by six trainees in neuroradiology familiarized with the method, but without experience in vertebroplasty. All of them answered a questionnaire about: the possibility, or not, of visualizing the spinal column within the closed shell, without radiological aid; the



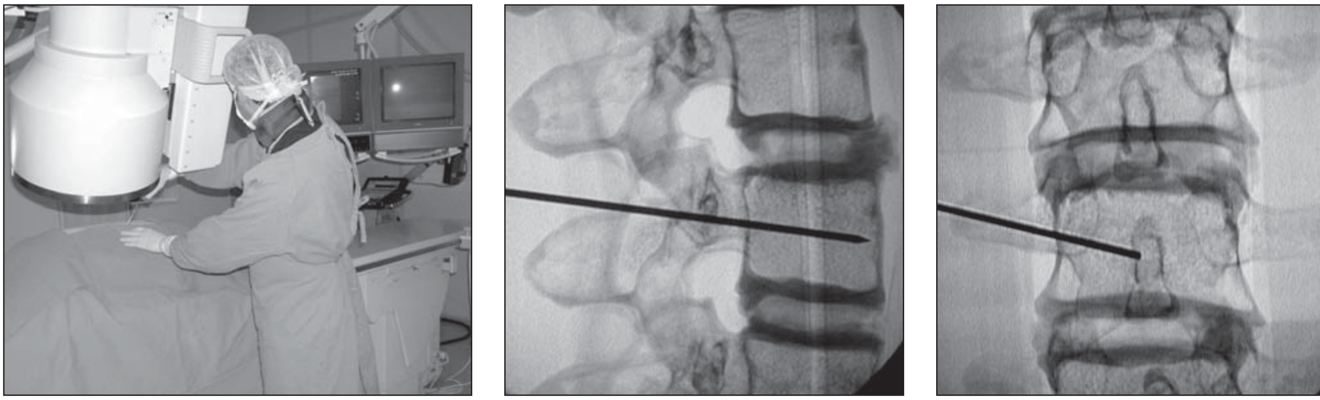
A

B

Figure 1. Simulator model. **A:** Model vertebra. **B:** Lateral view of the model vertebral column. **C:** Inner view of the shell containing the model vertebral column. **D:** Lateral view of the shell covered by a coat of ethylene vinyl acetate.

C

D



A B C

Figure 2. Procedure. **A:** An operator during training on the simulator model. **B:** Lateral radiographic view of the transpedicular puncture at the L3 level. **C:** Anteroposterior radiographic view of the transpedicular puncture at the L3 level.

possibility, or not, of identifying and individualizing the cortical and spongiosa layers at fluoroscopy and radiography; whether the respondents could perceive the differences between new and reutilized components; and finally, they were asked suggestions to improve the training model.

RESULTS

One hundred and seventy-two of the 180 procedures performed were considered as appropriate. Eight procedures were excluded because of a posterior displacement of the vertebra during the procedure due to a failure in the attachment of the vertebra to the shell structure.

Similarity data forms were filled in by all of the trainees following the procedures. All of them were unanimous as regards the non-visualization of the spinal column within the closed shell without radiological aid. All of them confirmed that they had observed a great anatomical similarity, a good visualization of the pedicle and cortical and spongiosa layers at fluoroscopy and radiography, as well as a clear tactile perception of these layers during the needle insertion. No significant difference was observed between new and restored components during the procedures.

As regards suggestions, three of the appraisers mentioned the low weight of the simulator model, allowing mobility of the trunk during the procedures. Four appraisers highlighted the necessity of intermediate planes simulating the musculature, just like in vivo procedures.

DISCUSSION

According to Kneebone & ApSimon[(9)], the effectiveness of a learning model based only on observation is questionable because it fails to stimulate a deep involvement of the trainee so the training is not effective. Therefore, skills acquisition, especially in the fields of surgery and interventional procedures, demands a sustained practice. On the other hand, the utilization of patients for practice and experience acquisition by trainees during their initial phase of education is unacceptable because of medical/ethical/legal concerns. So, the utilization of a simulator model constitutes an option for training, acquisition and evaluation of skills by means of a repeated safe practice[(10)].

The utilization of animal models has the disadvantage of high cost and poor reproducibility, besides difficulties of ethical nature[(9,11)]. Another difficulty would be the anatomical issue since the variability of animal models could represent a disadvantage in the definition of a paradigm, as pointed out by Gailloud et al.[(11)], in a study on the development of in vitro models for dural fistulas.

As regards the development of in vitro models, Bartynski et al.[(12)] and Kerber et al.[(13)] have shared the interest in alternative models, and, for the purposes of training and research, they have develop a model of arteriovenous malformation for simulating therapeutic embolization. In this context, the proposition of the present study is compatible with the idea of developing a non-animal model for guaranteeing the acquisition by interventional professionals of technical qualification previously to the performance of percutaneous vertebroplasty in patients.

According to Kneebone[(10)], in a study about medical education, simulators may be based on physical models, on the virtual reality, and on the so called hybrid models. The model described in the present study can be classified as a physical simulator model with a great technological appeal considering the wide range of materials involved in its construction. On the other hand, these training models are limited just to a body segment, and, for being inanimate, they do not allow a great model/operator interaction[(10)].

Panjabi[(14)] classifies the cervical spine models for biomechanical research as physical models, emphasizing its simplicity, low cost and low variability, considerations equally compatible with the simulator model proposed by the present study. On the other hand, this author affirms that physical models of the spinal column give little importance to the osseous anatomy and physical properties of adjacent soft tissues, and are principally utilized for surgical instrumentation testing. As regards anatomy, the results of the present study diverge from the Panjabi's assertion[(14)], since, despite the little concern with paravertebral structures, all of the appraisers (100% positive answers) observed a great anatomical similarity of the model with an actual patient, probably because the manufacture of this model was based on molds for components reproduction, as described by Gailloud et al.[11], and also because of vertebral layers stratification allowing a great visual similarity at fluoroscopy and tactile perception during the procedure.

Another aspect to be discussed is the reutilization of components. The restoration resulted in a satisfactory occlusion of the puncture site, and, due to the presence of the coat of ethylene vinyl acetate, the operator could not directly visualize the restored areas, not even by fluoroscopy. The reason probably is that the spongeous material of the internal layer refills the puncture pathway as soon as needle is withdrawn, so reducing the training costs.

According to suggestions from three appraisers, it is understood that some features of this simulator should be changed to increase the model similarity with the human body. Among them, the simulator weight should be increased to avoid mobility of the trunk during the procedures, and intermediate planes should be created to provide a tactile perception, particularly of the musculature, during the insertion of the needle through these planes.

CONCLUSION

The training simulator model described in the present study presents characteristics of similarity with *in vivo* procedure and should be considered as a potential tool for medical training in transpedicular puncture. The mentioned suggestions corroborate the aim at searching for material improvement and increase in realism.

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