IABP ballooning in Chinese patients

Gonzalo Pullas Tapia[1], Xiahua Zhu[1], Pan Liang[2], Gang Su[1], Hai Liu[1], Shuiqi Li[1]

[1]Cardiovascular Department, Zhengzhou University, Zhengzhou-China P.R, [2]Radiology Department, Zhengzhou University, Zhengzhou-China P.R

ABSTRACT

Introduction: The ischaemic disorders as a complication of intra-aortic balloon pump counterpulsation (IABP) could be deleterious in critically ill patients with myocardial failure and cardiogenic shock. This study is a pilot to predict the length of the descending aorta to select the optimum IABP size for Asian patients. **Methods:** The somatometric features from 80 Chinese patients were used: gender, age, height, body mass index, body surface area, trans-pyloric plane. Moreover, the aortic length from the origin of left subclavian artery to the orifice of the celiac trunk (LSA-CT) measured from tomographic scan examination. The variables to predict the length from the LSA-CT were studied in four types of predictive statistical analysis: nonlinear regression analysis, tree model, linear regression, and log_linear regression. The model was defined by obtaining the R square. **Results:** There were 59 males (mean age 53.9 years SD 13.2, height 170.8cm SD 4.0) and 21 females (mean age 58.7 years SD 7.8, height 160.2 cm SD 6.8). LSA-CT distance was found to be 279.5 SD 31.34 mm. The length of distance from the jugular notch to trans-pyloric plane was 273.8cm SD 12.5. The body mass index was 25.6 Kg/m2 SD 3.8 and the body surface area 1.8 m2 SD 0.1. The tree model for predicting the distance to the left subclavian artery to the celiac axis was chosen due to obtained an R2 square of 0,829. The comparison between the tomographic values and results of the tree model was realized with a nonparametric test. Wilcoxon signed-rank test showed that the values of computed tomograhy scan did not show a statistically significant difference with the results of the tree model (Z = -0.827 p =0.408). **Conclusion:** The tree model for predicting the distance from the left subclavian artery to the celiac trunk, could be an accurate guide to choosing an adequate catheter length of intra-aortic balloon pump counterpulsation in Asian patients.

Keywords: Complications by the use of intra aortic balloon pump, IABP, Intra aortic balloon pump, Length IABP catheter

INTRODUCTION

In current international guidelines intra-aortic balloon pumping (IABP) is used as cardiac assist device. The main purposes are to improve the peak diastolic pressure and coronary blood flow, to reduces end-systolic pressure and to increases afterload and myocardial oxygen consumption, in acute myocardial infarction with and without cardiogenic shock. Moreover, deliver a hemodynamic support in high-risk percutaneous coronary intervention, coronary artery bypass graft, mechanical complications of myocardial infarction and refractory ventricular arrhythmia.[1,2] The method to treat left ventricular failure by using counterpulsation or diastolic augmentation was first formulated by Harken in 1958.[1] Moulopoulos et al.[3] developed the IABP in 1962. However, Kantrowitz et al.[4] introduced this device into clinical practice in 1967. For clinical use, the balloon should cover the distance from the left subclavian artery to the celiac axis (LCA-CT) with the tip at the proximal ascending aorta below the origin of the left subclavian artery. The balloon should occupy 90 to 95% of the diameter of the descending aorta in each pumping cycle, for equals the aortic blood volume during diastole.[5] The commercial guidelines predict the LCA-CT length through the somatometric variable height as a selection process of the balloon size. Although, Parissis et al.[6] proved that the selection of the balloon length depending on the height shows a statistical significance but a relatively low consistency. According with this premise, they demonstrated that the transpyloric plane has a proper correlation with the LCA-CT distance in order to construct statistical models to select the counterpulsation balloon size. The inflation and deflation of the intra aortic balloon are synchronized to the cardiac cycle. In addition, proximal and distal displacement of blood volume in the aorta results during inflation at diastole. Deflation occurs just before to the onset of systole.[7] The clinical use of intra-aortic balloon pumping may have complications during its use. Are described thrombocytopenia, fever, bleeding, aorto-iliac artery injury and dissection, thromboembolism, distal leg ischaemia, balloon entrapment-rupture, also ischaemic renal failure or mesenteric ischemia by visceral artery obstruction.[8,9] The complication rates may account 50% according to Harvey et al.[10] with an average

Correspondig author:

Jing Xu, Professor, Cardiovascular Department, First Affiliated Hospital of Zhengzhou University, Jianshe Donglu, Zip Code 450000, Zhengzhou (China). E-mail: xujing00111@sina.com

20 to 30%.[8,11] Rastan et al.[12] identified IABP length mismatch, using computed tomography (ct) scans, in 68.2% of the cases, with severe adverse effects. Swartz et al.[13] found a reduction of 66% of renal function when the balloon blocked the renal arteries in an animal study. Clinical reports of intra-abdominal ischemia due to device length mismatch are reported.[14] Byon et al. identified in Asian patients, a potential balloon blocking of the celiac trunk in 61% to 84%, and the renal arteries in 10% to 66 %.[15] Therefore, the purpose of this study is to design an appropriate statistical model ease of use, robust, and undemanding interpretation to predict the length of the descending aorta. Finally, the aim was to facilitate the safe selection of the IABP balloon optimum size for Chinese patients.

METHODS

The present study accounted with 80 patients who received body tomography scanning. The study was approved by the ethical committee of the First Hospital Affiliated of Zhengzhou University and is in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. Furthermore, the patient's informed consent was signed. The exclusion criteria were patients with age less than 18 years old. Image interpretation was conducted in software for navigating in multidimensional DICOM images OsiriX®. The somatometric measurements from the patients were collected: One variable qualitative: gender. Also, six quantitative variables: age, height, body mass index (BMI), body surface area (BSA), trans-pyloric plane (M1). Moreover, the aortic length from the origin of left subclavian artery to the orifice of the celiac trunk through tomographic scan examination.

Anatomical Landmarks
The trans-pyloric plane in a halfway between the jugular notch and the upper border of the pubic symphysis was determined using a soft ruler of 150cm.[6] In addition, the patients were examined in a supine position.

Data Acquisition
Tomographic scanning was performed with 64-slice multidetector CT scanner (Somatom Definition Flash CT, Siemens Medical Solution, Forchheim, Germany). A standard protocol was applied as 128 × 0.6 mm of the section collimation, 0.28 seconds of the rotation time, 120 kV × 400 mA of tube current and voltage respectively, and 1 mm interval. A bolus of 100– 120 mL of nonionic contrast solution (Iopromide, 370 mg iodine per mL, Ultravist 370; Schering, Berlin, Germany) was intravenously injected, at a flow rate of 4 mL/s. Original images measured from 5mm interval tomographic scan examination were taken as a multidimensional DICOM images OsiriX®. Finally,

3D reconstruction surface and curved planar reformation of axial images were obtained of the aortic length from the origin of left subclavian artery to the orifice of the celiac trunk artery (Figure 1).

Statistical Analysis
The study data were analysed using the SPSS 20.0 statistical package program (SPSS Corp., Chicago, United States of America). Every continuous variable was presented as mean ± standard deviation, and the attributes were studied in four types of predictive statistical analysis: nonlinear regression analysis, tree model, linear regression, and log_linear regression. A larger R-squared defined the best model. The Shapiro-Wilk Test was used to verify the normality of the samples and the Wilcoxon signed-rank test for the comparison between LSA-CT and the results of the chosen model. A p value <0.05 was considered statistically significant.

RESULTS

The mean age of 80 patients was 55 ± 12,2 SD years (range, 20–84 years); 73.7% were men. The average height was 168 ± 6.7 SD cm (range, 148–178 cm). The length of LSA-CT was 272.5 ± 32.1 SD mm (range, 212.4–376.3 mm). LSA-CA in male was 279.5 ± 31.3 SD mm and female 253 ± 25.8 SD mm. The BMI was 25.6 Kg/m2 SD 3.8 and the BSA 1.8 m2 SD 0.1. The tree model showed an R2 square of 0,829 (Figure 2,3). The computed tomography scan values and the results of tree prediction not presented a normal distribution (Table 1), so a nonparametric test was used for the comparison of the paired data. A Wilcoxon signed-rank test showed that the values of computed tomography scan did not show a statistically significant difference with the results of the tree regression model (Table 2).

Figure 1: A: Curved planar reformation. B: 3D reconstruction surface of axial images images from the origin of left subclavian a rtery to the orifice of the celiac trunk artery.
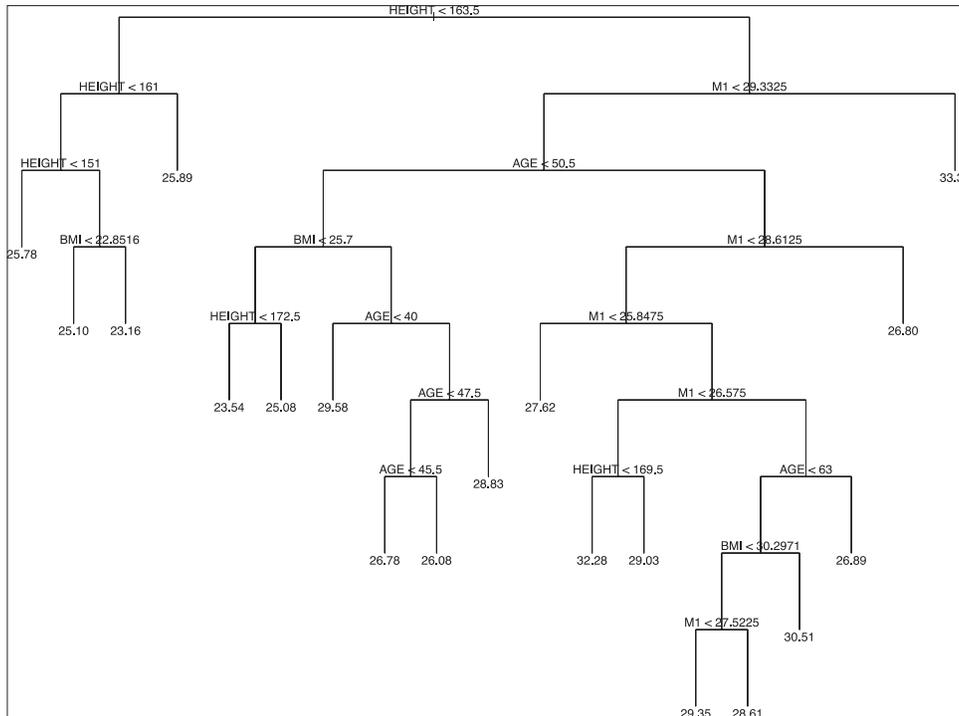
Figure 2: Tree prediction model. At each node, an observation goes to the left branch if and only if the condition shown at the node is satisfied.
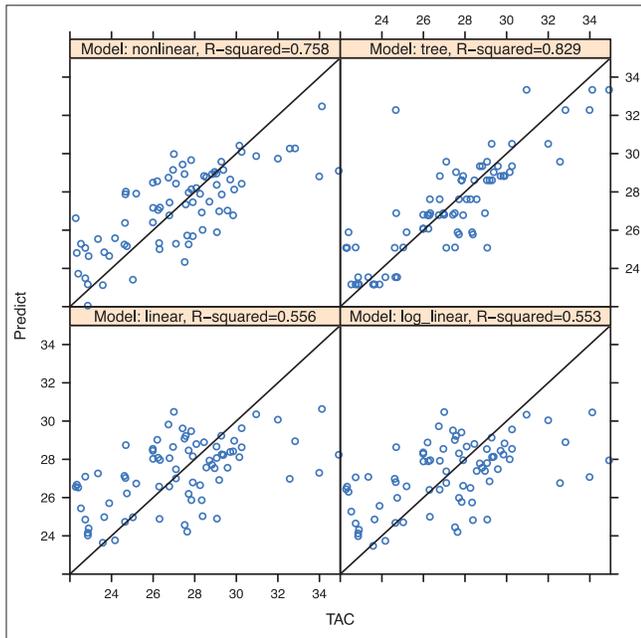

Figure 3: Scatter Plot Charts. Prediction and ct values (TAC): Nonlinear regression analysis, tree model, linear regression, and log_linear regression. R-squared values are displayed.

DISCUSSION

The intra aortic balloon counterpulsation has become a standard assist device of circulatory support, improving the peak diastolic pressure, coronary blood flow, and reducing the end-systolic pressure, afterload and myocardial oxygen

Table 1: LSA-CT prediction values and CT scan values test of Normality

	Kolgomorov-Smirnov			Shapiro-Wilk		
	Statitic	df	Sig.	Statitic	df	Sig.
PCT	0.095	80	0.077	0.952	80	0.004
CT	0.070	80	0.200	0.969	80	0.049

PCT: LSA-CT prediction values . CT: LSA-CT computed tomography values

Table 2: LSA-CT prediction values and ct scan values paired difference[b]

	PCT-CT[c]
Z	0.827[a]
Asymp. sig (2-tailed)	0.408

[a]Based on positive ranks. [b]Wilcoxon Signed Ranks Test. [c]PCT: LSA-CT prediction values . CT: LSA-CT computed tomography values

consumption. Despite its demonstrated usefulness in critically ill patients with myocardial failure and cardiogenic shock, the complication rate has remained high with an average 20 to 30%.[8,11] Major vascular complications during its use were reported about 1.4% in Benchmark registry[16] and 5.4% in Society of Thoracic Surgeon database.[17] Optimal outcomes require strict adherence to guidelines, because malposition of the IABP balloon could produce visceral artery compromise in up to 97% of patients.[12] Rastan et al.[12] described that despite correct balloon selection, the balloon had mismatched in 68.2% of the patients of his series. Apparently, the racial difference could be an important factor of obstruction of the visceral arteries. Cho et al. analyzed the relationship between aortic dimensions

and the length of the balloon in Asian patients, finding a mismatch in 44% of patients from 163 to 183 cm.[18] The commercial guidelines predict the LCA-CT length through the somatometric variable height as a selection process of the balloon size. The selection of the balloon length depending on the height indicates a statistical significance, but a relatively low consistency.[6] Whereby, the present study searched an accurate guide for calculate the distance of the aortic length to cover with the balloon catheter without risk of mismatch. The cardiac surgeons and intensive care specialists need tools for avoiding risks during their daily practice using IABP balloon counterpulsation. Therefore, the decision tree could be used as a safety guide to choose the length of the balloon suitable for each case. Furthermore, the imaging techniques to identify the proximal and distal position of the aortic balloon raise the proper use confirmation. Regarding the assessment of proximal balloon position for IABP patients, Rastan et al. found that chest radiography alone is inaccurate. So, he suggested that trans esophageal echocardiography, in spite its invasivity, could be useful to avoid risk of cranial atherosclerotic embolic debris. Computerized tomography scanning is a useful modality to detect the balloon position and aortic calcification but requires transport of a critical patient out of the ICU setting, not without risks. A recent study by Kim et al.[19] showed that the point 2 cm above the carina was more accurate as marker than the aortic knob. This anatomical feature has been established as a radiographic landmark for proximal landing area. For the assessment of distal position of the balloon, the authors suggest the use of abdominal ultrasonography as a simple method for avoiding the risk of occlusion of the visceral arteries. The result shows that the tree model as a multiple variable analysis of the somatometric attributes of the patients can reflect with accuracy the aortic length. The distance from the left subclavian artery to the celiac axis should be predicted in a precise way in order to match the length of the intra aortic balloon of counterpulsation, to avoid the arterial branches occlusion.

CONCLUSION

This study develops a statistical model that can assist in predicting the length from the left subclavian artery to the celiac trunk based on the clinical data of patients. Firstly, seven clinical features were selected: gender, age, height, body mass index, body surface area, transpyloric plane. Moreover, the aortic length from the origin of left subclavian artery to the orifice of the celiac trunk measured from tomographic scan examination. Secondly, the authors developed four types of predictive statistical analysis: nonlinear regression analysis, tree model, linear regression, and log_linear regression. Finally, the tree model to predict the length from the left subclavian artery to the celiac trunk, showed high consistency with the sizes of the aorta measured by ct scan. This model could be accurate to select the optimum size of intra-aortic balloon counterpulsation catheter.

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