ESTIMATION OF SIZE OF ASD CLOSURE DEVICE

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BACKGROUND

Atrial septal defects in majority of patients are oval / elliptical in shape with a difference in major and minor axis lengths. The devices used to close these ASDs are, however, circular. In clinical practice, there are no set guidelines to decide the size of the device to be used in patients with oval defects.

OBJECTIVE

The objective of this paper is to simulate placement of circular occluder in oval ASD and determine the diameter of ASD after expansion of occluder using mathematical models and simulation.

METHOD

Six dummy cases are selected for estimation of ASD closure device from simulation and mathematical model. The TEE size of the ASD at 0°, 40° and 90° are 16 mm, 19 mm and 24 mm for case I, 17 mm, 20 mm and 23 mm for case II, 18 mm, 20 mm and 22 mm for case III, 20 mm, 24.4 mm and 30 mm for case IV, 22 mm, 25 mm and 28 mm for case V and 24 mm, 25 mm and 26 mm for case VI. The IAS length is 28 mm for case I and II, 26 mm for case III, 34 mm for case IV, 32 mm for case V and 30 mm for case VI.

To calculate diameter of a circle after expansion of an oval ASD from a mathematical model, two assumptions are considered here, i.e., equality in (1) area and (2) perimeter of an ellipse, as compared to a circle. Assuming equality in area, the diameter of circle is

$$d = \sqrt{ab}$$

where a = major axis of ellipse, b = minor axis of ellipse. Assuming equality in perimeter, the diameter of circle is

$$d = \frac{a}{2}\left[3\left(1+\frac{b}{a}\right) - \sqrt{\left(3+\frac{b}{a}\right)\left(1+\frac{3b}{a}\right)}\right]$$

For simulation purposes, a simplified geometry of atria as spheres is used in ANSYS 14.5. The atria are declared as isotropic elastic and its density, Young's modulus and Poisson's ratio are assumed as 200 Kg/m^3, 100 KPa and 0.2 respectively. The closure device is also declared as isotropic elastic with Density 200 Kg/m^3, Young's modulus 2e9 Pa and Poisson's ratio 0.48.The pressure is applied in the radial direction on the device and expansion is calculated.

RESULTS

The final diameter of ASD obtained from simulation is compared with those using mathematical models and they matched with 99 % confidence interval using Chi-square test. The percentage error is found to be lesser in case of equality of perimeter.

CONCLUSION

Diameter of the device calculated by the mathematical equation presuming equality of perimeter correlates better with simulation results than the equation which assumes areas to be equal. With the latter, the error tends to minimize further with increase in the defect size.