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Original Research Article

Study of Morphological Characteristics of Fossa Ovalis and Its Clinical Importance - A Cadaveric Study

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Abstract

Transseptal access from right atrium to left atrium through the fossa ovalis using transseptal puncture and patent fossa ovalis repair are widely used cardiac techniques. These techniques require through knowledge of the cardiac anatomy especially of the fossa ovalis .Evaluation of the various morphological parameters of the fossa ovalis forms an important prerequisite before undertaking any surgical procedure in this region. This study was conducted on 60 cadaveric hearts from the department of Anatomy, Government medical college, Nagpur. The right atrium was opened and the fossa ovalis was studied for its shape, size, floor and the prominence and extent of the limbus fossa ovalis was noted. The fossa ovalis was observed for the presence of any patent foramen ovale or probe patency. In majority of the cases the shape of fossa ovalis was found to be oval 66.7% cases, the average craniocaudal diameter was found to be 15.03mm, and average anteroposterior diameter was found to be 14.44mm. Limbus fossa ovalis was found to be raised in 83.33% cases and flat in 16.66% cases. Probe patency of foramen ovale was found in 15% cases but no case of patent foramen ovale was found. The floor of fossa ovalis was found to be flat in 65% cases and aneurysmal in 35% cases. In 10% cases membranous structure with multiple fenestrations or fine strand like structures were seen attached to the lower part of fossa ovalis. The findings of the present work are of immense value to interventionists and cardiologists.

Keywords: Foramen ovale, fossa ovalis, patent foramen ovale, limbus fossa ovalis, probe patency of foramen ovale, transseptal puncture.

INTRODUCTION

Fossa ovalis is the postnatal representation of foramen ovale.It is located in the right and posterior portion of atrial septum.It is formed by the fusion of two septa, septum primum and septum secundum and left valve of sinus venosus [1]. The floor of fossa ovalis is represented by septum primum and its limbus is represented by septum secundum [2].

Fossa ovalis has been widely studied embryologically but little attention has been given to the morphology in normal adult heart.

Probe patency of the foramen ovale is seen in 15-35% of the population but patent foramen ovale is more common in the general population [3]. Patent foramen ovale leads to a number of complications like migraine, cryptogenic stroke, decompression sickness in divers, and platypnea orthodeoxia due to shunting of blood between right and left atrium [4]. Transeptal catheter closure is the preferred surgical technique for patent foramen ovale [5]. This surgical technique is associated with high success rate, lower incidence of post operative complications and excellent long term follow up results [6-8]. However the closure is not without risk and may lead to major haemorrhage,cardiac tamponade and fatal pulmonary emboli in 1.5% and minor complications like atrial arrthymia, device embolisation,device thrombus and AV fistula formation in about 7-8% cases [9].

To optimize the patient outcome careful assessment of the various morphological parameters of fossa ovalis including its rim is done echocardiographically for successful device closure of patent foramen ovale [10]. Very few studies have reported the morphological parameters of fossa ovalis in adult cadaveric hearts [11, 12].

Therefore this study is undertaken to evaluate the morphological characteristics of fossa ovalis and also its annulus. These findings are of great importance

in selection of appropriate device for closure of patent foramen ovale.

MATERIALS AND METHODS

This study was conducted on 60 apparently normal cadaveric hearts from both sexes utilised for undergraduate teaching programme in the department of Anatomy, Government Medical College, Nagpur. The interior of right atrium was opened by an incision just in front of sulcus terminalis and fossa ovalis was observed for the following parameters.

- Shape of fossa ovalis was observed (circular, oval, elliptical)
- Craniocaudal and anteroposterior diameters of fossa ovalis were recorded by 0.03mm precision electronic vernier calliper in mm.
- Floor of fossa ovalis was observed for presence of aneurysm and presence of right sided septal pouch.
- Extent and location of limbus.
- Presence of patent foramen ovale.

OBSERVATIONS/RESULTS

a) Shape of fossa ovalis

The shape of fossa ovalis was found to be oval in 40cases (66.7%), circular in 12 cases (20%) and elliptical in 8cases (13.33%) (Figure-2).

b) Size of the fossa ovalis

In the present study the average craniocaudal diameter was found to be 15.03mm, (range 7.76 - 24.42mm) and average anteroposterior diameter was found to be 14.44mm (range 7.28 – 19.57mm) (Figure-1).

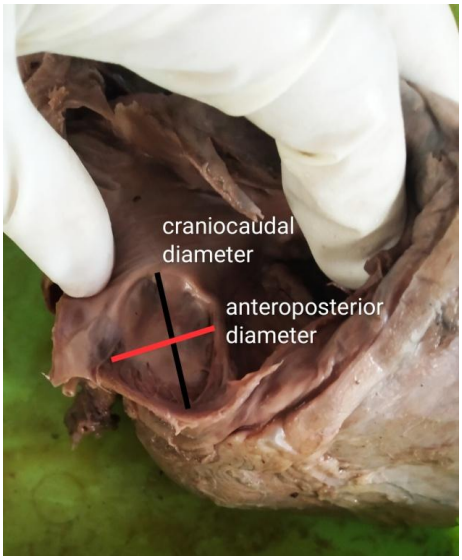

Fig-1: Showing the craniocaudal diameter (indicated by black line) and anteroposterior diameter (indicated by red line)

c) Limbus fossa ovalis/Annulus

- Limbus fossa ovalis was found to be raised in 50 cases (83.33%) and flat in 10 cases (16.66%)
- Segment of the annulus that was prominent
  - ➢ All round the margin in 18 cases (30%)
  - ➢ Superior in 7 cases (11.66%), superior anterior and posterior
  - ➢ Superior, anterior and posterior in 3 cases (5%)
  - ➢ Posterior and inferior in 4 cases (6.66%)
  - ➢ Posterior in 2 cases (3.33%)

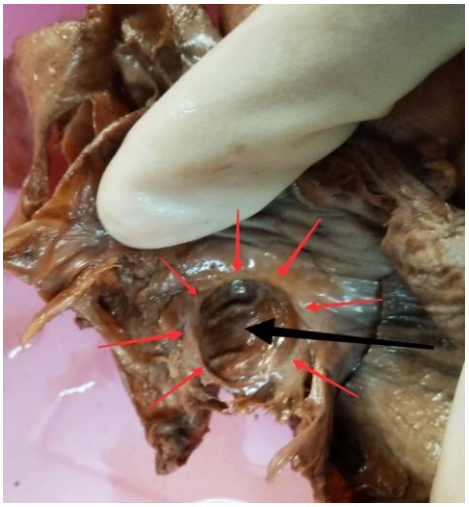

Fig-2: Showing the circular shape of fossa ovalis.Red arrows indicate the raised margins of the the limbus fossa ovalis all round the fossa. Black arrow shows the aneurysm of the floor of fossa ovalis bulging towards the left atrium

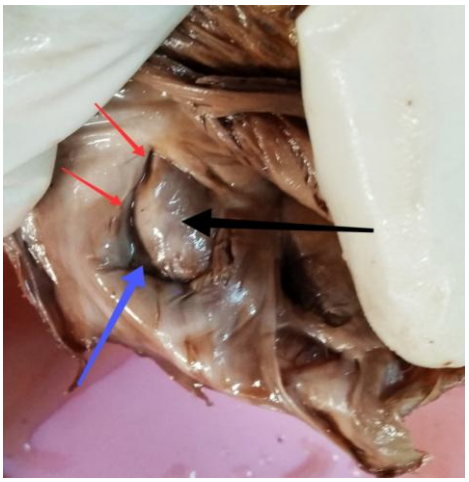

Fig-3: Red arrow shows the raised limbus fossa ovalis. Black arrow shows the aneurysm of the floor of fossa ovalis. The aneurysm is bulging towards the right atrium. Blue arrow indicates the septal pouch opening in the right atrium

d)Recess In Relation To Annulus

Slit like recess was found in 33 cases (55%) and deep recess was found in 9 cases (15%) (Figure-5).

The septal pouch is defined as invaginated portion of septum in absence of patent foramen ovale as a result of incomplete fusion of embryological components of interatrial septum [13].

In our study we found 2 case of right sided septal pouch. The pouch opened in the right atrium and was present in the anterior part of fossa ovalis in one case and in the posteroinferior part of fossa ovalis in another case (Figure 2 & 3).

Probe patency of foramen ovale was found in 9 cases (15%) but no case of patent foramen ovale was found (Figure-5).

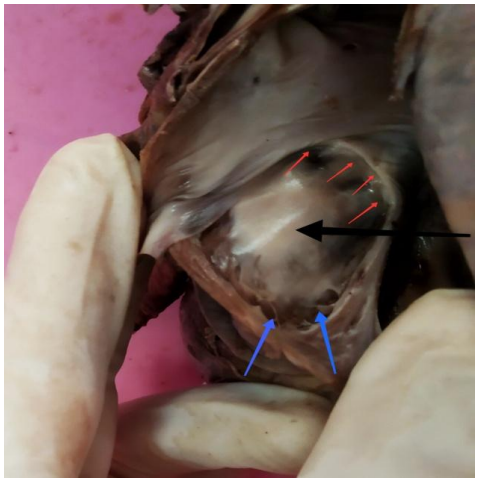

Fig-4: Showing the oval shape of fossa ovalis.Red arrows indicate the presence of slit like recess. Blue arrow shows membranous structure with multiple fenestrations in anteroinferior part of fossa ovalis. Black arrow indicate the aneurym of the fossa ovalis bulging towards right atrium

e) Floor of fossa ovalis

The floor of fossa ovalis was found to be flat in 39cases (65%) and aneurysmal in 21cases (35%).Out of this the fossa ovalis was found bulging towards right atrium in 14 cases (23.33%) and towards left atrium in 7 cases (11.66%)

In 6 cases out of the 60 cases studied (10%) the floor of the fossa ovalis was not smooth.

In 4 cases membranous structure with multiple fenestrations were seen attached to the lower part of fossa ovalis whereas in 2 cases, fine strand like structures extended from anteroinferior part of fossa ovalis to the limbus (Figure 4 & 6).

Fig-5: Showing the probe patency of the foramen ovale. Black arrow indicating the probe passing through the foramen ovale from right atrium to the left atrium

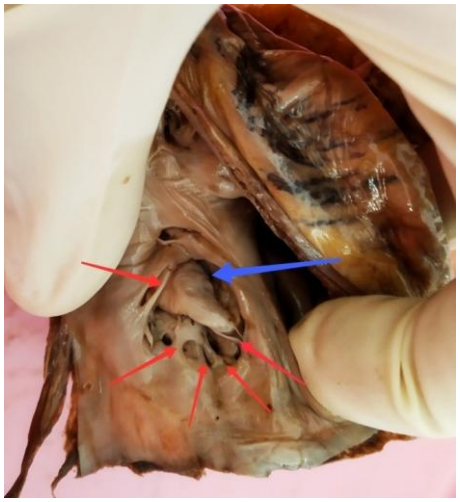

Fig-6: Showing the uneven floor of the fossa ovalis. Red arrows indicate thick and thin strand separated by multiple fenestrations extending from the fossa ovalis to its limbus. Blue arrow shows presence of right sided septal pouch in the anterior part of fossa ovalis

DISCUSSION

From the clinical point of view, the fossa ovalis is considered as a three dimensional structure. Embryologically this complex septum is contributed by endocardial cushions, septum primum, septum secundum and septum spurium [14].

At the end of 4th week septum primum grows from the roof of primordial atrium towards the fusing endocardial cushions. The opening between the free cresentric edge of septum primum and endocardial cushions is called foramen primum. Later this foramen becomes progressively smaller as the septum primum fuses with the endocardial cushions to form primordial AV septum. Before this, perforations begin to develop in the central part of septum primum by apoptosis. These perforations coalesce to form foramen secundum. During the 5th and 6th week septum secundum is a thick cresentric muscular fold which grows from the ventrocranial wall of right atrium. The lower free concave edge of septum secundum begins to overlap foramen secundum. The left venous valve and septum spurium fuse with the right side of septum secundum. The passage between the two atrial cavities consists of an oblique cleft between the two septa allowing the blood to flow from right atrium to left atrium. At birth when the lung circulation begins the pressure in the left atrium increases, the septum primum is pressed against the septum secundum obliterating the foramen ovale [15, 16].

In the present study the mean anteroposterior diameter of fossa ovalis was found to be 14.44mm and the mean craniocaudal diameter was found to be 15.03mm. Study by S. D. Joshi *et al*., in 2016 have reported the average anteroposterior diameter of fossa ovalis to be 14.53mm and average vertical diameter of 12.60mm[11].Wieslawa Klimek Piotrowska *et al.*, have reported the mean anteroposterior diameter of fossa ovalis 14.1mm and the mean craniocaudal diameter to be 12.1mm [17], whereas Kydd C *et al*., studied the dimensions of fossa ovalis by transoesophageal echocardiocardiography and found the anteroposterior diameter 17mm and superoinferior diameter 19.44mm [18].

The shape of fossa ovalis in the present study was found to be oval in 66.7% cases, elliptical in 13.33% cases and circular in 14% cases. S. D. Joshi *et al*., have reported the shape of fossa ovalis to be oval in 82%, elliptical in 4% and circular in 14% cases [11]. Wieslawa Klimek Piotrowska *et al*., have reported the shape to be oval in 55.6% and round in 44.4% cases [17].

This can be explained on the basis of findings of Hanaoka T *et al*., who stated that although the hearts are normal the size and location of fossa ovalis varies from heart to heart, also the shape of fossa ovalis is variable [19].

According to Wieslawa Klimek Piotrowska *et al*., fossa ovalis has a floor surrounded by rims. The superior, anterosuperior and posterior rims are infolding of the adjacent right and left atrial walls which incorporate extra cardiac adipose tissue. Puncture at these points leads to damage to the outer wall of the heart. The true "septum secundum" is the antero-inferior buttress, which binds the septum to the atrioventricular junctions [17]. The thickness of the rim is due to the extra cardiac tissue, usually adipose tissue contained in this fold [5]. The thickness varies between individuals. The rim thickness is important parameter analysed before the device closure of patent foramen ovale. The rim thickness not only helps to define the morphological phenotype of patent foramen ovale but also decides whether or not the device will fit properly for the complete closure of patent foramen ovale. If the surrounding rim is excessively bulky, the disc of the device will not be able to fit properly against the fossa

ovalis. A smaller size or softer type of device is considered in such cases [5].

The prominence of the rim varies between individuals. In our study the limbus fossa ovalis was found to be raised in 50 cases (83.33%) and flat in 10 cases (16.66%). Scwinger *et al*., found flat rims of the fossa ovalis in nearly 20% cases [20]. S. D. Joshi *et al*., found annulus fossa ovalis was raised in 90% cases, and flat in remaining 10% cases [11]. In our study annulus was prominent all round the margin in 18 cases (30%), superior in 7 cases (11.66%),

Superior, anterior and posterior in 3 cases (5%), Posterior and inferior in 4 cases (6.66%), Posterior in 2 cases (3.33%). In the literature reviewed, we did not find the detailed study of this parameter.

In the present study slit like recess was found in 33 cases (55%) and deep recess was found in 9 cases (15%) where as S. D. Joshi *et al.*, found deep recess in 20% cases with a depth ranging from 5-10mm and slit like recess in 8% cases [11].

In our study we found 2 cases of right sided septal pouch. Wieslawa Klimek Piotrowska *et al*., observed septal pouch opening to the right atrium in 11.9% of specimens. He also observed septal pouch opening to the left atrium in 51.2% of specimens [17].

Septal pouch occurs when the patent foramen ovale is absent, but the small pocket within interatrial septum can be shown [13]. The presence of the right sided septal pouch is undesirable as this may imitate the patent foramen ovale. Additional caution should be taken during manipulation of septal pouch. Due to the thin nature of the wall, excessive force even by blunt catheter may cause damage to the tissue. If the right sided septal pouch is in close proximity to the aortic sinus excessive force while guiding catheter through the septal pouch may damage the aortic sinus [17].

No case of patent foramen ovale was found in our study but probe patency was seen in 9 cases (15%). Probe patency occurs due to incomplete postnatal fusion of the septum primum and septum secundum leaving a narrow oblique cleft between the two, but this does not allow intracardiac shunting of blood [21].

Probe patency was seen in 18% cases in the study by S. D. Joshi *et al*., [11]. Silver and Dorsey reported an incidence of probe patency as 50% [22] and Marelli *et al.*, have reported an incidence of 25% in general population [23]. Rana *et al.*, have reported an incidence of 25– 35% [5]. Davison *et al.*, found it in 15–35% [4]. Bergman et al have also mentioned its incidence as 25% [24].

In the present study the floor of fossa ovalis was found to be flat in 39cases (65%) and aneurysmal in 21cases (35%). Out of this the fossa ovalis was found bulging towards right atrium in 14 cases (23.33%) and towards left atrium in 7 cases (11.66%).

Aneurysm is a localized out-pouching of the fossa ovalis region of the atrial septum. Formation of this aneurysm is due to abnormally elevated intracardiac pressure due to extrinsic factors [25]. On Topaz *et al*., did a detailed study of 33 cases of fossa ovalis aneurysm and found 24 aneurysm (73%) protruding into the right atrium and only 9 (27%) protruding into the left atrium [25]. Anthony Pearson et al., found aneurysmal fossa ovalis in 1% of autopsies but by TEE, it was found to be 8% [26]. Gianluca *et al*., found aneurysm of the fossa ovalis in 0.22–4% in general population but it rises to 8–15% in patients with stroke [10]. Kydd *et al*., observed atrial septal aneurysm in 12% [18]. S. D. Joshi *et al*., found the floor of fossa ovalis was flat in 70%, aneurysmal in 14%, and redundant in 16% [11]. The higher incidence may indicate that these individuals are more prone to thromboembolic phenomenon.J Shrirani *et al*., reported a higher incidence of patent foramen ovale in patients with fossa ovalis membrane aneurysm. They found patent foramen ovale in 14 (70%) cases with fossa ovalis aneurysm.

Mitral valve prolapse, dilated atria, intracardiac thrombi are frequently seen in association with fossa ovalis membrane aneurysm [27].

In our study out of 6 cases (10%) in 4 cases membranous structure with multiple fenestrations were seen attached to the lower part of fossa ovalis whereas in 2 cases, fine strand like structures extended from anteroinferior part of fossa ovalis to the limbus. These represent remnants of the embryonic left venous valve of sinus venosus. During the embryonic life the left venous valve fuses with the right side of of interatrial septal complex. If this fusion remains incomplete, the remnants of left venous valve are found adherent to the to the fossa ovalis [28]. These structures may present difficulty during catheter manipulations and transeptal closure of patent foramen ovale.

Thus the morphology of fossa ovalis is important in planning and conducting transeptal puncture procedures. Transseptal access through fossa ovalis is commonly employed during the following procedures: catheter ablation, pulmonary vein isolation, left atrial appendage closure, patent foramen ovale and atrial septal defect repair, percutaneous mitral valvuloplasty, MitraClip catheter-based mitral valve repair, hemodynamic assessment of the mitral valve, paravalvular leak closure [17].

CONCLUSION

Transseptal puncture through fossa ovalis and transcatheter closure of patent foramen ovale are widely used cardiac techniques. Thus evaluation of the various

morphological parameters of fossa ovalis becomes mandatory before undertaking the surgical procedure not only for selecting the proper device but also for successful closure of patent foramen ovale. So the findings of the present work should be of immense value to interventionists and cardiologists.

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