Comparison of thicknesses of the myocardial fibers of anencephalic and normal human fetuses

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When heart transplantation is needed in newborns, brain death should be confirmed, and the heart should not be exposed to hypoxia. The anencephalic newborn has been presented as a donor in heart transplantation. It is important, therefore, to evaluate possible morphological differences in the hearts of anencephalic cases. In this study, muscle fibers were studied in 10 anencephalic and 10 normal fetuses (27-35 weeks) and the results were compared. Random samples were taken from the upper 1/3 of the right ventricle's posterior wall and processed for light microscopic examination. Thicknesses of the 100 myocardial muscle fibers for each fetus were evaluated. There was statistically no significant difference between the anencephalic and normal fetus groups and the sex groups. Morphological features of the transplant probably affects the performance of the heart after operation. The anencephalic fetuses could be unique donors for heart transplantation.

Key words: anencephaly, heart transplantation, fetal heart, light microscopy, human fetus.

In this study we aimed to compare the thicknesses of the myocardial muscle fibers in anencephalic and normal fetal hearts. It is important to evaluate the possible morphological changes in anencephalic cases, and no microscopic study on this subject exists in the literature to our knowledge.

Use of anencephalic fetuses as donors in heart transplantation has been presented in the literature[1-3]. Heart transplantation in newborns is accepted as an effective treatment for congenital heart diseases such as cardiomyopathies and endocardial fibroelastosis and in some cases of tricuspid atresia, which are not compatible with life[1,4-7-9]. In such a procedure, brain death should be confirmed, and the heart should not be exposed to hypoxia. However, it is not easy to find a donor that meets both conditions, and this lack of suitable donors is the most important factor restricting heart transplantation[1,2,4-6,7,10].

Material and Methods

In this study 10 anencephalic (8 female, 2 male) and 10 normal fetuses (6 female, 4 male), aged between 27 and 35 weeks, were used. The fetuses were fixed with 10% formalin solution.

For the estimation of the fetal age, foot lengths were measured and compared with Mercer's scale[11].

Atrium walls were removed to obtain tissue samples from the ventricular walls. Random samples were taken from the hearts. Tissue specimens were taken from the upper 1/3 of the right ventricle's posterior wall, including all three layers of the heart, for the evaluation of the ventricular wall thickness. Tissues were embedded in paraffin blocks. Five-micron thick sections were taken and stained with H&E.

On each slide, 100 heart muscle fiber thicknesses were measured. The measurements were taken from around the nuclei where the muscle fibers thicknesses were largest. The arithmetic mean for each slide was taken, so in each group 10 arithmetic means were attained. Results were statistically compared both for the groups and for sexes. Factorial analysis of variance technique was used.

Results

The evaluation of the muscle fibers of the anencephalic and normal human fetuses by light microscopy showed that there were no obvious differences between the two groups. The muscle fiber density and structure of the two groups were found similar. Cytoplasmic solidity, nuclei and striated structure of the heart muscle fibers were of normal appearance (Figs. 1, 2).

Data obtained from the statistical analysis of myocardial fiber thickness of the anencephalic and normal fetus groups are given in Table I. The mean ± SE mean values of the myocardial muscle fiber thikness were 50.25±3.16 μ (SD=8.93) and 38.01±4.85 μ (SD=6.86) for female and male fetuses, respectively, in the anencephalic group. The mean±SE mean values were 43.04±1.87 μ (SD=4.59) for female and 43.60±4.02 μ (SD=8.03) for male fetuses in the normal fetus group. Minimum and maximum values were 43.25 μ-69.32 μ for female anencephalic fetuses and 33.16 μ-42.86 μ for male anencephalic fetuses. Minimum and maximum values of the normal fetus group were 37.66 μ-49.76 μ and 38.76 μ-55.54 μ for normal female and male fetuses, respectively.

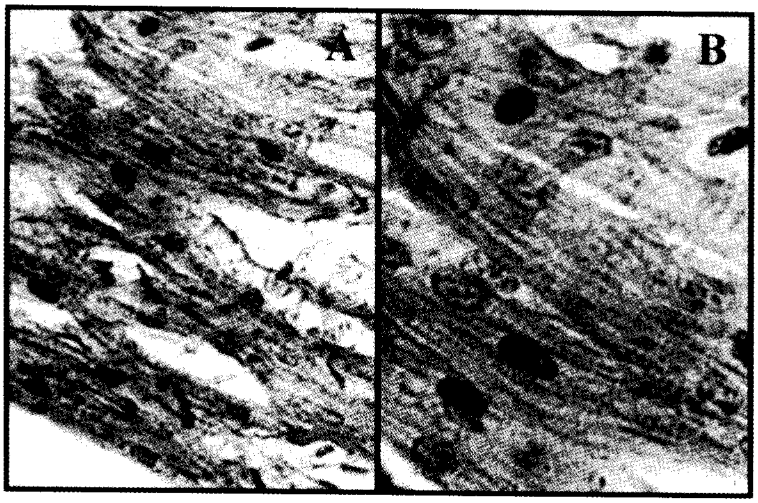

Fig. 1. Muscle fibers of the anencephalic fetus under the light microscope (A: X200 and B: X400, HE stain).

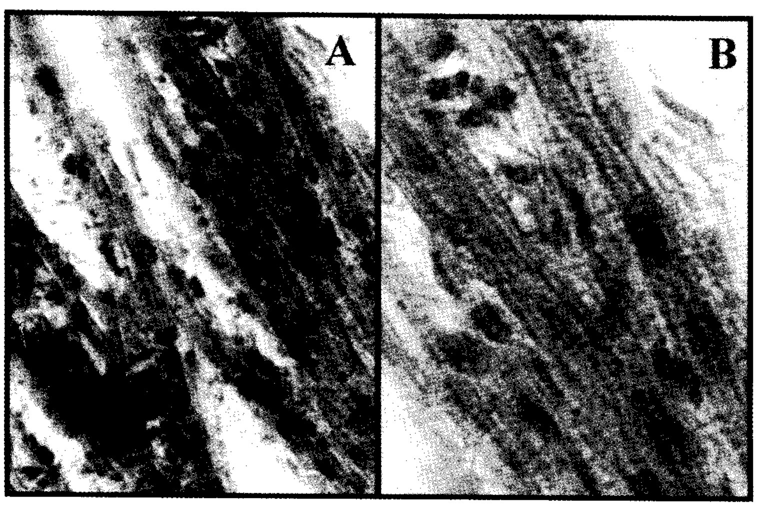

Fig. 2. Muscle fibers of the normal fetus under the light microscope (A: X200 and B: X400, HE stain).

Table I. Statistical Comparison of Myocardial Fiber Thickness Between Anencephalic and Normal Fetuses and Sexes

Group	Sex	Mean±SE mean (μ)	Standard deviation (μ)	Minimum (μ)	Maximum (μ)
Anencephalic	female	50.25±3.16	8.93	43.25	69.32
	male	38.01±4.85	6.86	33.16	42.86
Normal	female	43.04±1.87	4.59	37.66	49.76
	male	43.60±4.02	8.03	38.76	55.54

Statistically, no significant differences were found between the two fetus groups (p=0.196) or between genders (p=0.159). Furthermore, fetus group sex interaction was not statistically significant (p=0.169). Therefore, differences between anencephalic and normal fetus groups were not significant according to sex. Likewise, differences between gender groups were not significant for the anencephalic and normal fetus groups.

Discussion

Although a high number of organ anomalies are seen in anencephalic newborns, a specific heart anomaly is not mentioned in the literature[12-14]. There may be morphological differences between anencephalic and normal fetal hearts as a result of certain abnormalities at different developmental stages.

In postnatal life, progressive increase in heart load (in pathological states such as in hypertension and anemia, and in physiological states such as in strenuous exercise) causes myocardial fiber hypertrophy as a compensatory response. There is an increase in the rate of protein synthesis, the amount of protein synthesis in each cell, the size of mycoytes, the number of sarcomeres and mitochondria and consequently the mass and size of the heart due to the compensatory mechanism[15]. Likewise, in the fetal period brain tissue takes an important percentage of the blood pumped by the heart. In anencephalic newborns absence of any vascular bed of the brain is thought to decrease the heart load. In anencephalic fetuses, as the need for blood is less, the heart load should also decrease. Thus, it is possible that the myocardial fibers might undergo morphological and ultrastructural changes.

Effect of the cerebral cortex via the autonomic nervous system and the medulla has been shown on the fetal heart rate and the rhythm of the heart. Although only the medulla controls the fetal heart rate according to the studies performed in anencephalic and normal fetuses intrauterinely at 27-28 weeks, it has been shown later that it is under the control of the developing cerebral cortex[16-18]. Studies have also shown that the fetal brain affects the diurnal rhythm of the fetal heart rate and contributes to synchronous maternal-fetal rhythm. It has also been reported that the cerebral cortex is the origin or a transmission route for the response of fetal heart rate to acoustic stimulation[18-20]. For these reasons, there may be differences in the establishment of the fetal heart rate between anencephalic and normal fetuses, especially after the 27th week of intrauterine life.

Furthermore, removal of CSF (cerebrospinal fluid) or air invasion into the cerebral ventricles and impairment of intracranial hydrodynamics cause electrocardiographic alterations[21]. Neuronal stimulation not only affects the heart rate, but also the strength of contractibility[22]. In view of recent data, absence of brain tissue may affect functions of the heart. However, investigations of how these effects are reflected in the myocardial fibers, which are the functional units of the heart, do not exist in the literature.

General morphological features of the transplant probably affects the performance of the heart after the operation and may assist heart surgeons in determining the donor. In this study, thicknesses of the myocardial fibers were studied, and no differences between the two fetus groups was found. The results indicated that neither decrease in the heart load nor deficiency in autonomic innervation was reflected in the myocardial fiber thickness in the upper 1/3 posterior wall of the right ventricle. Considering the effects of the cerebrum on the heart, the anencephaly itself seems to be the reason for certain pathological changes. The results of this study showed that there is no statistically significant difference between the thicknesses of the muscle fibers of normal and anencephalic fetuses in the right ventricle's posterior wall. However, these results may not be similar for the other regions of the heart, and thus, further investigation is needed in these two groups for other walls of the heart.

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