PERCUTANEOUS BALLOON ANGIOPLASTY AND VALVULOPLASTY FOR STENOTIC CONGENITAL CARDIAC DEFECTS

A THESIS

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By

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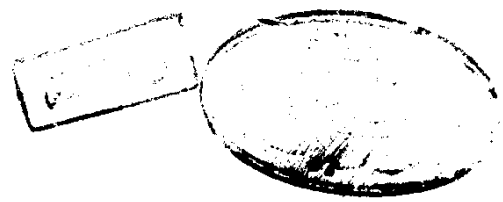

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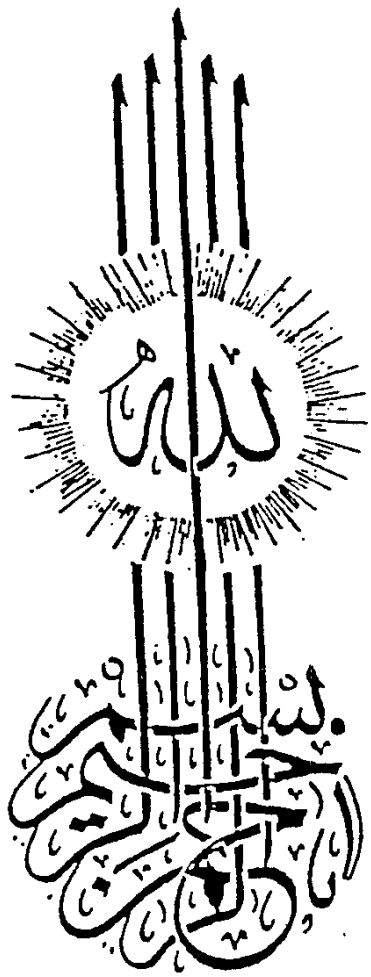

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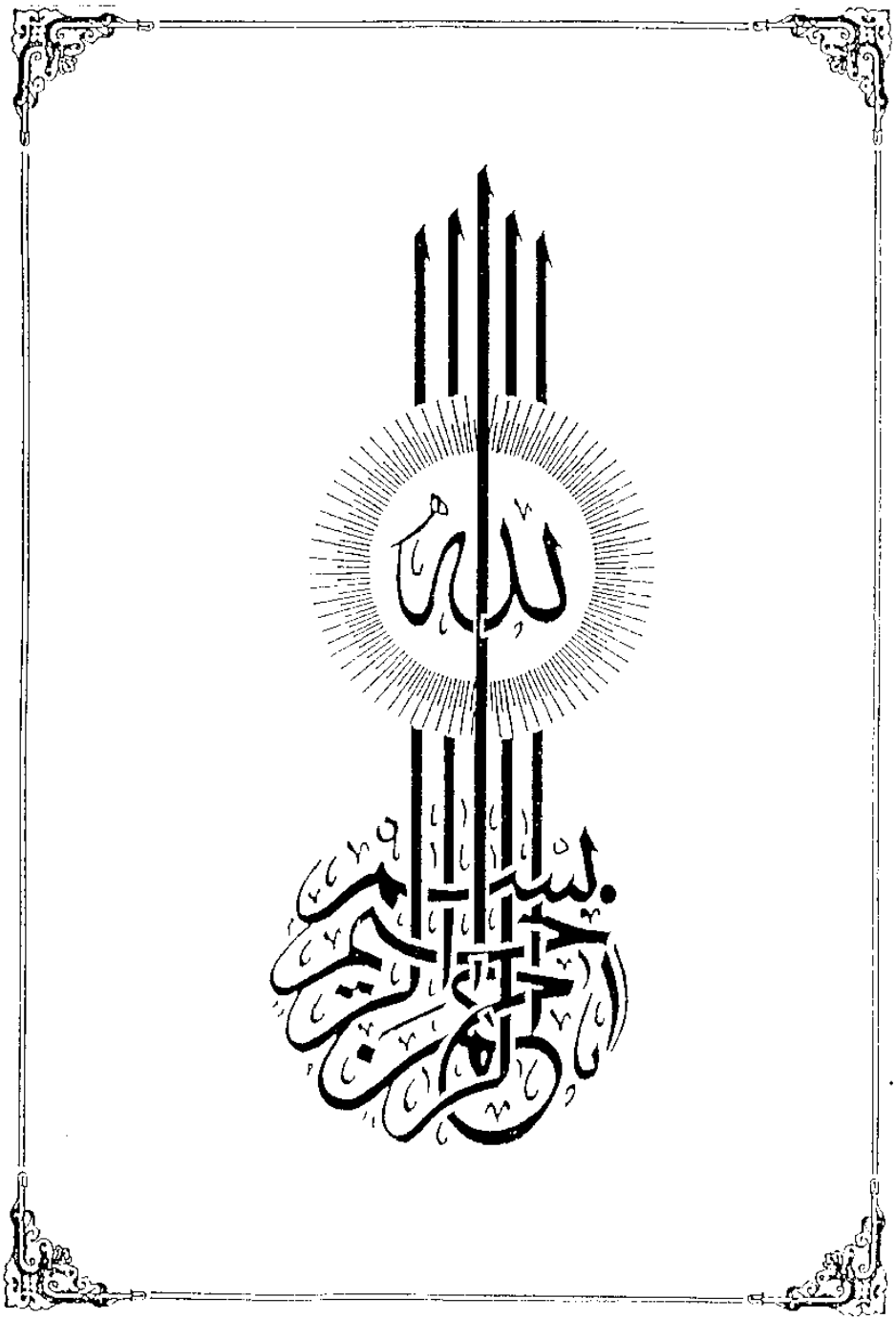

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TO MY FAMILY WHO SUPPORTED ME

THROUGHOUT THIS WORK

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ABBREVIATIONS

AVS = aortic valvular stenosis.

BAV = balloon aortic valvuloplasty.

BCA = balloon coarctation angioplasty.

BMV = balloon mitral valvuloplasty.

BPV = balloon pulmonary valvuloplasty.

CMS = congenital mitral stenosis.

COA = coarctation of the aorta.

DSS = discrete subaortic stenosis.

DSSD = discrete subaortic stenosis dilatation.

LVOT = left ventricular outflow tract.

PACs = premature atrial complexes.

PDA = patent ductus arteriosus.

PPS = peripheral pulmonary stenosis.

psi = pounds per square inch.

PVCs = premature ventricular complexes.

PVS = pulmonary valvular stenosis.

spg = systolic pressure gradient.

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Invasive catheterization and dilatation are not new. References to crude instruments date back to the ancient Egyptians and Romans who used reeds for dilating the urethra. The first use of a balloon catheter was reported in the early 1800s when a catgut balloon was used to dilate the urethra.(20)

Numerous mechanical devices for dilation of the cervix, esophagus, urologic tract, and blood vessels have existed for centuries. Except for changes in the type of materials used, they have remained unchanged in design. Hundreds of bougies, olives, and rodlike instruments with various curves and tapers have been designed to fit particular anatomic narrowings. Most bear the name of the physician who originated the specific design. Moving-action, leverage-type devices have also been in existence for a long time. However, the smaller ones cannot be used in applying great force. In addition they are quite fragile and because of the friction involved, do not work very well around corners. Recently a number of transcatheter techniques for opening clogged arteries have been advanced, including ultrasonic emulsifiers and "Roto-Rooter" type devices that can "eat" into clot and withdraw it through the catheter.(21)

The first attempts to relieve congenital vascular narrowings with catheters were reported more than 30 years ago.(1)

To overcome arteriosclerotic narrowing and occlusion in the arteries of the leg, Niles and Dotter[22] in 1963 proposed an approach that has led to the development of a safe, simple, and effective technique. In 1964, Dotter and Judkins[2] demonstrated that atherosclerotic plaques could be modified by passing large angiographic catheters coaxially through a narrowed and diseased arterial lumen. Their technique was based on the observation that during arteriography, guide wires and catheters could be passed through stenotic and even occluded arterial segments. Their[2] first patient was treated on January 16, 1964. They[2] used a coaxial Teflon catheter system consisting of a 12 French catheter introduced over an inner 8 French catheter through a percutaneous femoral approach. As the "Dotter technique" began to be used (primarily in Europe), some of its users found that a coaxial catheter system was not necessary in every case. The coaxial catheter technique of angioplasty was criticized because of local complications which occurred at the puncture site when such large catheters (12 French) were introduced percutaneously. In addition, objections were raised to the potential damage caused by the shearing force applied as the large catheter is advanced through the lesion. Moreover, technical limitations at the puncture site precluded dilatations to greater than 4 mm which was usually

inadequate for large diameter iliac vessels and generally limited the application of the technique to femoral dilatations.(25)

Variations on this approach included that first described by Staple(23) in 1968, where he used a single 8, 10, or 12 French catheter with gradual tapering of its tip over a 0.038 inch guide wire. The theoretical advantage of the Staple catheter over the coaxial system of Dotter and Judkins was that with the gradual tapering of a single catheter and the elimination of the non-tapered outer catheter the damage to the vessel intima (due to the so-called "snowplow" effect) would be reduced. Later Van Andel(24) of Holland described the use of gradually tapered catheters made to specification known as the Van Andel tapered catheters.

Latex balloons were tried, but met with little success because of their tendency to inflate in the direction of least resistance and thus only soft lesions could be dilated with these.(26) To get around this problem, Portsmann(27) in 1973 described the use of a caged balloon catheter (Korsett-Katheter). He(27) expanded a balloon within a short segment of an outer catheter that had been slit longitudinally so as to form a reinforcing cage. Unfortunately, although it applied more force, it produced a lot of debris and a rough surface.(26)

In 1974, Gruntzig and Hopff(28) introduced the double-lumen balloon dilatation catheter. This nonelastic "rigid" balloon was

made of polyvinyl chloride and, because of its compliance, it could be inflated to a predetermined diameter (4-8 mm), and a pressure of 4-5 atmospheres could be applied to an atherosclerotic plaque with no risk of balloon and vessel overdistention. The obvious advantage of the balloon catheter over previous systems was that one can dilate the vessel to a 12 French size using only a 7 French catheter, thus reducing the rate of complications at the catheter insertion site.(28)

The Gruntzig balloon dilation catheter was introduced for use in percutaneous transluminal angioplasty of the iliac and femoropopliteal arteries. Since then, its uses have expanded to include angioplasty of the renal(29), coronary(30) axillary, carotid, subclavian, celiac, superior mesenteric, and hypogastric arteries-(31-33), and of the abdominal aorta(34), as well as dilation of vein graft stenoses(35), stenotic angioaccess dialysis fistulas and shunts(33), postoperative arterial anastomotic stenoses in renal transplant patients(36), portosystemic venous shunts(37), and Blalock-Taussig anastomoses. The catheter has also been used to dilate strictures of the biliary systems, including biliary-enteric anastomoses(38), ureteral strictures(39), gastroenterostomy stomas, and acquired stricture of a main bronchus.(40)

Recently, percutaneous transluminal balloon angioplasty has been applied in pediatric cardiology to treat pulmonary valve