Fetal Lower Urinary Tract Obstruction

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KEYWORDS

- Obstructive uropathy • Lower urinary tract obstruction
- Antenatal diagnosis and management
- Fetal surgery/intervention • Bladder shunt

Prenatal ultrasonography often identifies fetal urinary tract anomalies, with detection possible as early as 12 to 14 weeks of gestation. Obstructive abnormalities of the urinary tract are common and observed in approximately 1% of pregnancies. Fortunately, most of these have little clinical significance, and only approximately 1 in 500 pregnancies is complicated by significant fetal urologic malformations. The challenge, however, is prenatal identification and development of a coordinated prenatal and postnatal management plan directed at optimizing clinical outcomes in cases with potential postnatal morbidity and mortality. This article focuses on the causes and consequences of lower urinary tract (urethral) obstructions (LUTOs).

EARLY EXPERIMENTAL MODELS

Natural History of Obstructive Uropathy

The natural history of obstructive uropathy is highly variable and depends on gender, severity, duration, and age of onset of the obstruction. Complete obstruction of the urethra early in gestation can lead to massive distention of the bladder, hydroureteronephrosis, and renal fibrocystic dysplasia. Inability of the urine to enter

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the amniotic space results in oligohydramnios, leading to pulmonary hypoplasia and secondary deformations of the face and extremities. Outcome is measured in terms of postnatal survival and depends on two factors: pulmonary development and renal function. Of these, pulmonary development may be the more critical for neonatal survival.

Pulmonary hypoplasia and prematurity are the leading causes of mortality in obstructive uropathy. In cases of posterior urethral valves (PUVs), there is a 45% mortality rate that can be directly attributed to pulmonary insufficiency.[1] This high mortality is generally not reflected in postnatal urologic series of lower urinary tract obstruction (LUTO); it represents the ''hidden mortality'' of this disorder, because these infants do not survive for transfer to a pediatric specialty center for treatment. Early midgestation oligohydramnios carries a poor prognosis for the fetus, and when associated with urethral obstruction, the mortality rate has been estimated to be as high as 95%.[2,3] Therefore, fetuses with oligohydramnios and LUTO represent the most severe end of the obstructive uropathy spectrum and are at highest risk for pulmonary hypoplasia and renal dysplasia.

A sheep model of surgically created urinary tract obstruction reflecting the pathophysiology observed in human fetuses was developed in the early 1980s.[4,5] The effects of ureteral ligation at 62 to 84 days of gestation (total gestation period in sheep is 144 days) on renal histologic findings were found to depend on when in gestation the ureteral obstruction occurred. Using a combination of urachal ligation and gradual occlusion of the urethra, pulmonary hypoplasia, bladder dilatation, hydroureters, and hydronephrosis resulted. This model produced histologic changes in the kidneys similar to those seen in humans, with increased fibrosis throughout the kidney, although no parenchymal disorganization or cysts were observed, which are frequent findings in humans. A sheep model was then developed to determine if in utero decompression was beneficial.[6] Urethral obstruction was established at 95 days, after which half of the animals underwent suprapubic cystostomy after 15 to 27 days of obstruction, allowing urine to flow freely from the obstructed fetal bladder. Cystostomy resulted in universal survival with minimal need for respiratory support, in contrast to high mortality and need for maximal respiratory support in the first 24 hours of life in those without decompression. These studies demonstrated that restoration of amniotic fluid volume (AFV) resulted in improved lung growth and pulmonary survival. All lambs that had undergone cystostomy had mildly dilated urinary tracts and minimal histologic renal parenchymal damage. Although no evidence of cystic dysplasia was observed, fibrosis was prominent throughout the kidneys of lambs that had not been decompressed.

Renal cystic dysplasia and disorganized architecture similar to those occurring in humans was produced in the sheep model when ureteral ligation was performed earlier in gestation (58–66 days of gestation). Fibrosis and parenchymal disorganization were present, and the medullary region contained abnormal-appearing ducts.[6] To determine whether in utero relief of obstruction would prevent renal dysplasia, unilateral ureteral obstruction at 58 to 66 days of gestation was performed, followed by end-ureterostomy to relieve obstruction at 20, 40, and 60 days after obstruction. Duration of obstruction was directly related to the likelihood of deterioration in renal function and occurrence of histologic change. Decompression, regardless of timing, improved histologic findings and function compared with controls that had not been decompressed, however, and provided evidence that in utero decompression of early obstruction could arrest histologic changes, prevent severe dysplastic damage, and potentially preserve renal function.