Amniotic Fluid

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1. Introduction

The chemical constituents of amniotic fluid, which acts as a protective physical "cushion" for the fetus, have yielded valuable information for prenatal diagnosis, allowing increasingly accurate assessment of fetal physiology and metabolism. Since the amniotic fluid can be viewed as an extension of the fetal extracellular space (Lind et al., 1969; Lind and Hytten, 1970), an understanding of its origin, formation, and chemical constitution is crucial to continued progress in prenatal diagnosis and fetal therapy. Cellular components are discussed in this chapter and in Chapter 4.

2. Amniotic Fluid Dynamics

2.1. Formation and Circulation

Knowledge about the anatomic pathways of formation and circulation of the amniotic fluid remains incomplete (Seeds, 1974; Ostergard, 1970; Fuchs, 1966; Delecour et al., 1970). Fluid exchange between the fetus and the mother probably occurs via a number of routes and through different mechanisms, and may vary according to the stage of gestation. Large volumes of fluid are transferred across the fetal membranes, which are made up of five layers of amnion and four layers of chorion (Bourne, 1966). Electron microscopy of the amnion has revealed a complex system of tiny intracellular canals, which in turn are connected to the intercellular canalicular system and the base of the cell (Bourne, 1962). The structure of the amniotic cavity is basically complete by about 10 weeks' gestation (Hamilton et al., 1964). It has been suggested from studies in primates that the amniotic fluid is a transudate of the maternal plasma and becomes like other fetal fluids in the presence of the fetus, which
contributes urine and other body secretions to the amniotic fluid space (Behrman et al., 1967). Osmotic or diffusion permeability, hydrostatic pressure, chemical gradients, and other mechanisms are responsible for the fluid exchange between fetus and mother (Seeds, 1974).

During the second trimester of gestation, total amniotic fluid turnover is complete within about 3 hr (Cox and Chalmers, 1953; Hutchinson et al., 1955; Plentl and Hutchinson, 1953). About 20 ml of amniotic fluid/hr is swallowed by the fetus, that is, about 500 ml/day (Pritchard, 1965, 1966). At term, the exchange rate between fetus and mother may approach 500 ml/hr (Hutchinson et al., 1955, 1959). Active renal function is evident from the ability of the fetal kidney to concentrate radioopaque substances given intravenously to the mother, thereby allowing visualization of a fetal pyelogram (Thomas et al., 1963).

Several amniotic fluid compounds reach a maximum or minimum level toward the end of the second trimester (Morgan and Hytten, 1984). Understanding of the fetomaternal metabolism is of the utmost importance in the evaluation of fetal development and in particular in the antenatal diagnosis of fetal demise.

Although the fetus depends largely on the placenta for the transport of nutrients, it is also protected from marked fluctuations in maternal metabolism. As stated by Clewell et al. (1984), “Since the fetal kidney cannot serve as a final excretory organ in utero, its function in fetal life has been obscure.” It is generally accepted that amniotic fluid is mainly produced by the fetal kidney as pregnancy progresses and that oligohydramnios may reflect renal structural anomalies or general growth retardation.

2.2. Volume

The magnitude of fluid exchange is also uncertain. Interference with disposal in the routes of fluid production by a factor affecting only 1% of the volume may result in a significant increase or decrease in the total amniotic fluid volume by as much as 1 liter in 10 days (Hibbard, 1972).

Various techniques have been used for the direct estimation of amniotic fluid volume. Comparable results have been reported utilizing dilutional techniques, radioactive materials, or various dyes or chemicals (Ostergard, 1970; Fuchs, 1966). Nelson (1972) measured amniotic fluid volumes in 46 cases prior to 20 weeks’ gestation, and summarized data culled from four other published series (Table I and Figure 1). A highly variable although similar range of amniotic fluid volumes was observed in other studies (Wagner and Fuchs, 1962; Rhodes, 1966; Abramovich, 1968; Gillibrand, 1969). The mean volume appears to be about 207 ml at 16 weeks (Nelson, 1972) and close to 400 ml at 20 weeks (Fuchs, 1966). Queenan et al. (1972) measured 115 amniotic fluid volumes from 15 to 42 weeks’ gestation by the p-aminohippurate method and found similar results with a wide normal range and no decrease at term. Later Bhatt and co-workers (1978) confirmed previously reported values for the second trimester. The accuracy of ultrasonic measurements of intra-amniotic volume using a parallel planimetric area method was assessed using a dye dilution method during the second trimester and at term (Geirsson et al., 1984). The parallel planimetric area method was found to carry acceptable table accuracy.

An incremental rise in volume of about 25 ml/week occurs from 11 to 15 weeks’