Ultrastructural and morphometric study of the glomerular filtration slit during neonatal period

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Abstract:

Background

The functional and morphological development of the glomerlus is an essential part of nephrogenesis that takes place during Intra uterine life and early post-natal days.

Objectives

To study the morphometric parameters of the maturation of the glomerular filtration slit of the kidney during neonatal period and its implication on the function of the kidney.

Method

Rat litters are used as a mammalian model of the development during the first 8 days of post -natal life. Image analysis using Bell software system was used for morphmetric measurement of filtration silt as examined by electron microscope.

Results

The width of the filtration slit of new born kidney was 11.24±1.6 nm which increased by increment to be 14.83±1.6 nm on 4th .post- natal day. Eventually reached 25.34±4.3 nm on day 8 post natally.

Conclusions

In New Born litters, the glomerular filtration slit is narrower than that of mature kidney. Glomerular development continues to take place during first post natal week to reach the adult mature parameters at the end of neonatal period. This explains the low GFR found in new born mammals.

Key Words: Glomerulus, Development, GFR

Introduction

During the fetal life, the kidneys are not responsible for excretion, since the placenta serves this function, However, the acquisition of physiologic or functional capability begins with the earliest formation of the fetal nephron and accelerates to reach mature levels.
Studies of the glomerular filtration rate and plasma creatinine concentrations shows a low glomerular filtration rate and high plasma creatinine during the first days of life (1). Analysis of the underlying mechanisms contributing to low glomerular filtration rate in immature kidney concentrates on hemodynamic factors and influences including arterial blood pressure, capillary pressure, afferent glomerular arteriolar resistance and arterial plasma protein concentration. This study approaches the problem of low

neonatal glomerular filtration rate from a morphological point of view by analysis of glomerular filtration slit. The filtrate of plasma passes through the filtration barrier between the blood and urinary space. This barrier is composed of fenestrated endothelium, the glomerular basement membrane, and podocyte foot processes with interposed slit diaphragm (membrane) (2).

Materials &Methods

This study was performed on albino rat (Rattus rattus norvegicus albinus), as a mammalian model .New born litters we studied for each post-natal day, in a daily sequence from the first to the 8th post natal day. Four litters were dissected for each day, the kidney was retrieved. The samples used were prefixed in 2.5% buffered gluteraldhyde pH (7.4), then post fixed in 1% osmium tetraoxide. Dehydration was done in graded ethanol, cleared in acetone and embedded in araldite embedding resin (Eimscope).
Semith in section were examined first, then ultrathin 60-80 nm thick were examined after staining with uranyl acetate and lead citrate. Philips CM10 transmission electron microscope was used to obtain electron photo micrograph of the glomerular filtrations lits. Image analysis and morphometry was performed using BEL micro Image analysis Software (2006).The electron micrographs were standardized at 31000 x magnification. For measurements BMP image format was used. The values were calibrated into (nm).

Results

The electron micrographs showed the ultrastructural features of podocytes and glomerular filtration barrier. The podocytes gave secondary foot processes or pedicles. These pedicles came in direct contact with the basal lamina of the blood capillary. The foot processes that came from different cells interdigited with each other to form the filtration slit of the filtration barrier.The glomerular filtration barrier was composed of fenestrated end of the lium and showed three zones of varying electron density. Centrally is the electron-dense "lamina densa", with, on each side, the more electron- lucent "lamina rara externa" and "lamina rara interna".A thin membrane, called the filtration slit membrane bridged the gap between adjacent foot processes (refer to Figure 1). The results of morphometric measurements of the filtration slit width during the post natal days are shown in table (1).

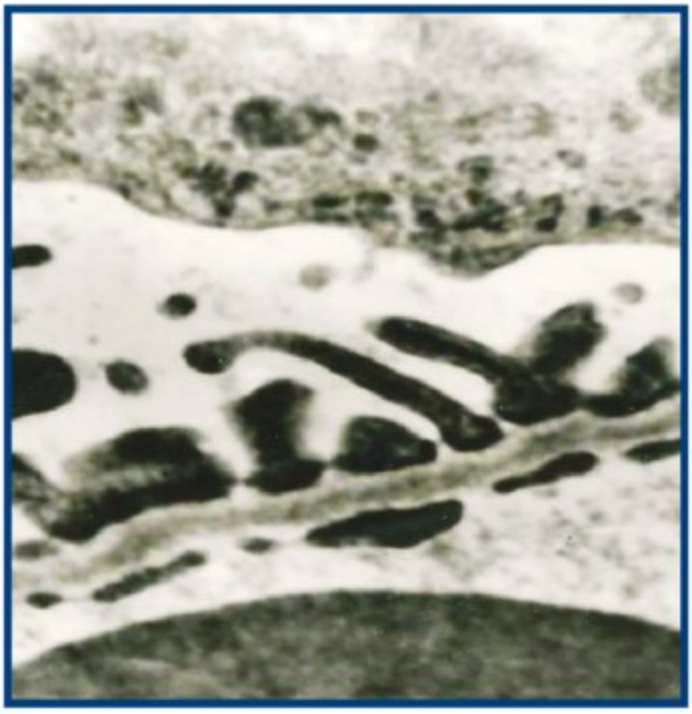

Figure (1) Transmission electron micrograph of glomerular filtration barrier Uranyl acetate & lead citrate 31000x

Table (1) Filtration Slit Diameter (nm) During Post-natal days

Post-natal day	Filtration diameter Mean ±S.D. (Nm)
1	11,24±1.6
2	11.84±1.5
3	12.89±1.6
4	14.83±1.6
5	16.09±3.6
6	17.42±3.2
7	21.14±3.2
8	25.34±4.3

Discussion

This work showed that the width of the filtration slit at birth is (11.24±1.6) nm) which is evidently less than that of adult mature kidney that varies from (25-60 nm) (3).In adult mature rat, the width of the filtration slit is (39 nm) (4), and the data of healthy human suggest a slit width similar to the tofrat. The mean width of filtration slit in huma n is (43 nm) (5).

Durin g the neonatal period, the width of the filtration slit increases by gradual increm ent to reach a value within the range of the mature adult r at by the end of the first week, to be (25.34±4.3 nm) at 8th post natal day.

In general, renal development in volves two basic processes; morphological formation and acquisition of function. In this study, it is shown that rat kidney development continues during the first post-natal week, by the end of which, the morphometric parameters of the filtration slit will be within functional range.

For comparison human nephrogenesis is completed by the 36th week of gestation (6). The acquisition of physiological or functional capability begins with the earliest formation of metanephric

nephrons and accelerates after birth to reach adult levels. In this study the first week of post-natal life is a "critical" period for morphological and functional development of the glomerulus .Our findings in this respect are in the same line of evidence of other workers (7). At birth several dramatic takes place to alter the renal function. On top of these events is the cessation of the role of the placenta as an excretory organ. The placenta is the essential organ of excretion during in trauterine life. The change of the milieu after birth makes the kidney the primary factor in maintaining homeostasis. The success of the kidney to attend morphological and function al maturity during the first week of life is an essential physiological process.

There is some controversy concerning the maturational pattern of the glomerular filtration rate (GFR).The GFR values at term are lower than those observed in adults on absolute basis or when corrected for body weight, body surface area or extra cellular fluid volume (8).The analysis of underlying mechanisms contributing to the low GFR in immature kidney concentrates, so far, on hemodynamic factors and influences, including arterial blood pressure, capillary pressure, afferent glomerular arteriolar resistance and arterial plasma protein concentration.

This study approaches the problem of the low neonatal GFR differently. It concentrates on non hemodynamic factors. The current investigation of the anatomical and morphological features of the neonate kidney revealed a smaller width of the filtration slit in the filtration barrier, as well as the continuation of development of the kidney from the embryonic life to the first week of postnatal life. The morphometric finding of this study points to a low filtration coefficient in Starting law of glomerular filtration rate as the reason behind low GFR in early post natal kidney.

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