West of England Medical Journal

Formerly Bristol Medico-Chirurgical Journal

The e-journal of the
Bristol Medico-Chirurgical Society

WEMJ Volume 116 No.3 Article 1 September 2017

Neonatal polycythaemia, blood viscosity, microcirculatory haemolysis and jaundice*

Peter M. Dunn, MA, MD, FRCP, FRCOG, FRCPCH
Emeritus professor of perinatal medicine and child health, University of Bristol, UK
e-mail: P.M.Dunn@bristol.ac.uk

* Based on a communication to the Neonatal Society, Keele University, June 28th, 1991[1]

In 1963 I came to work at Southmead Hospital, Bristol to study fetal adaptation to extra-uterine life.

One of my main studies involved investigating the impact of the placental transfusion on the baby. I did this by studying two groups of healthy term infants in a randomised controlled trial (RCT), one group of which had had their umbilical cords clamped at the moment of birth while in the second clamping had been delayed for three minutes[2,3].

Whole mean cord blood haematocrit values for both groups were identical (mean haematocrit 52%). The subsequent heal capillary haematocrits (and haemoglobin values) of both groups followed very different trajectories (Fig 1). Those of the infants with delayed cord clamping usually rose to over 70% and even to over 80% due to the placental transfusion and to a transitory shift of plasma out of the vascular compartment into the tissues – 'the postnatal plasma shift'.

This was my first introduction to significant neonatal polycythaemia and of its importance soon after birth. At the time (1964) paediatric and neonatal texts made no mention of the subject except in an occasional reference in relation to the twin-to-twin syndrome
(Fig 2).

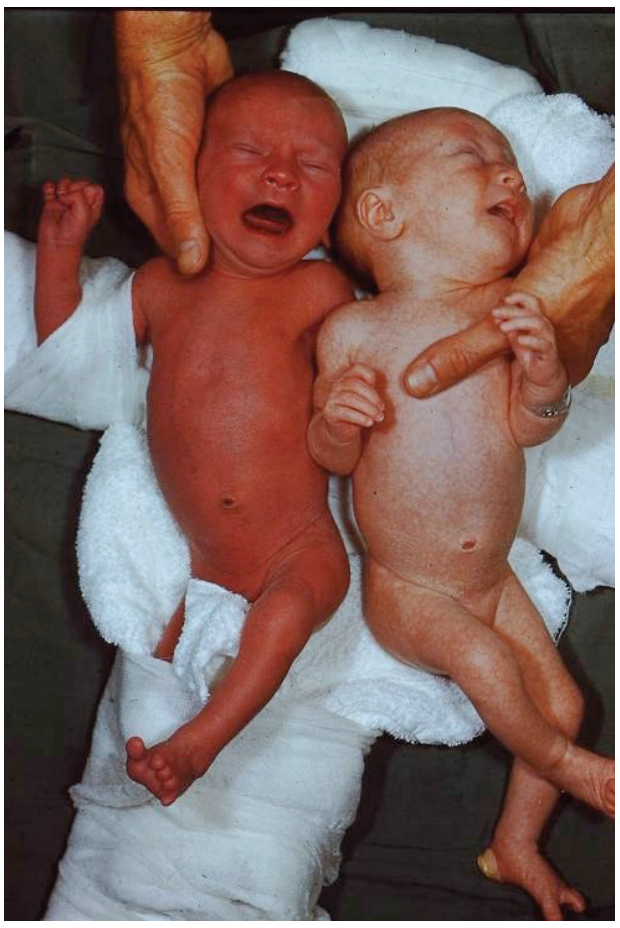

Fig 2.
Identical twins born following a twin-to-twin transfusion.

As I was working single handed I not only collected all the heel prick blood specimens (in triplicate) but also made the estimations of the haematocrit using an Hawksley micro-haematocrit centrifuge. I then placed the serial haematocrit capillary tubes for each infant during the first one to two days of life in sequence and photographed them in colour (Fig 3).

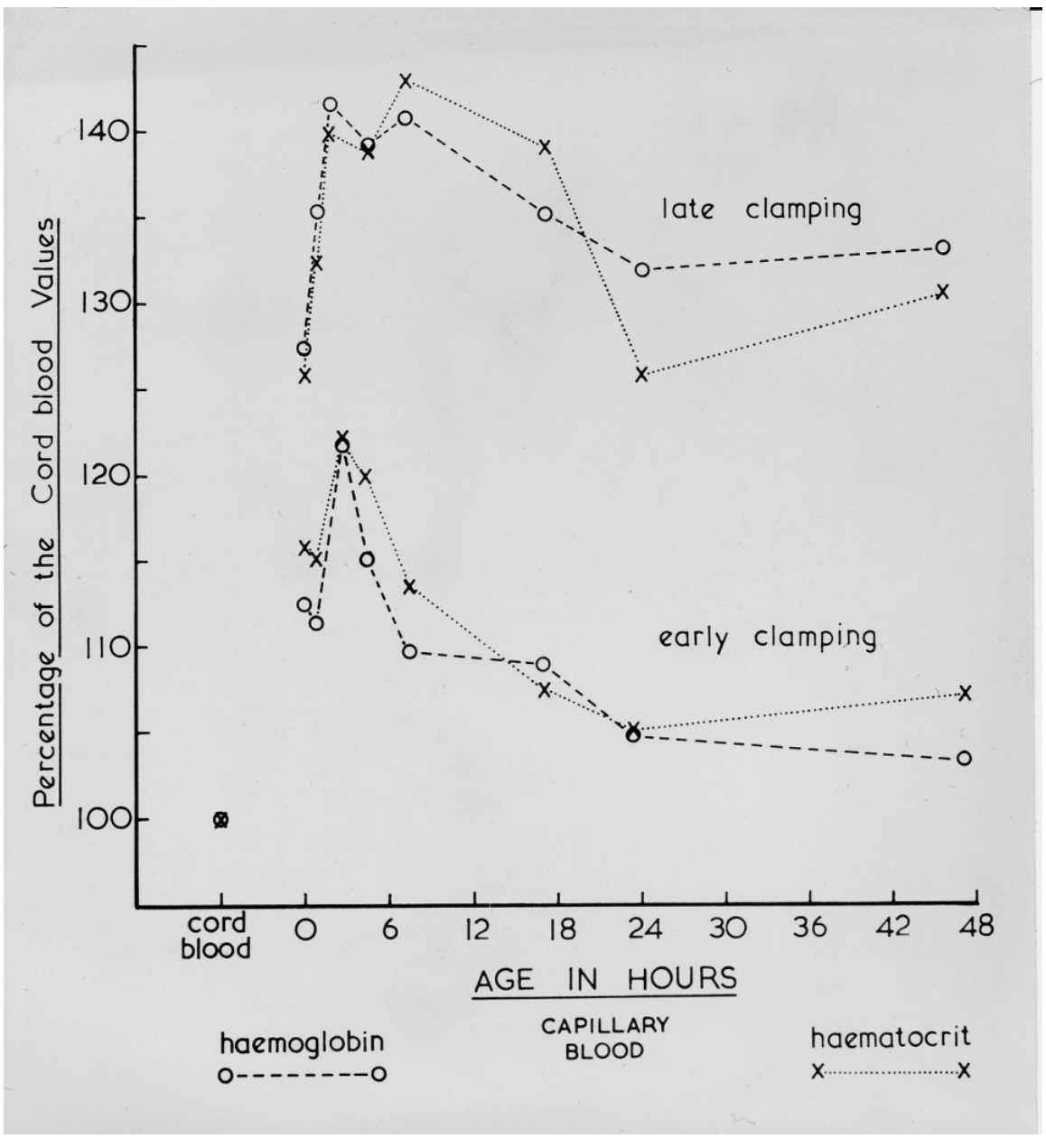

Fig 1.
Mean haemoglobin and haematocrit values during the first two days of life of two groups of normal vaginally delivered term infants (RCT) (n=30) that had either had their umbilical cords clamped at the moment of birth or after a delay of three minutes . Values are expressed as a percentage of the mean cord blood values[2,3].

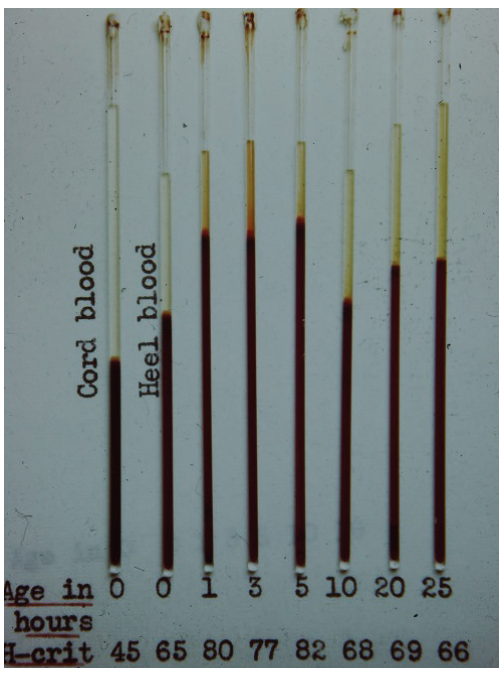

Fig 3.
Serial capillary haematocrit tubes from an infant in the late cord clamped group. Note the pink supernatent plasma when the haematocrit level was above 77%.

West of England Medical Journal

Formerly Bristol Medico-Chirurgical Journal

The e-journal of the
Bristol Medico-Chirurgical Society

Neonatal polycythaemia, blood viscosity, microcirculatory haemolysis and jaundice WEMJ Volume 116 No.3 Article 1 September 2017

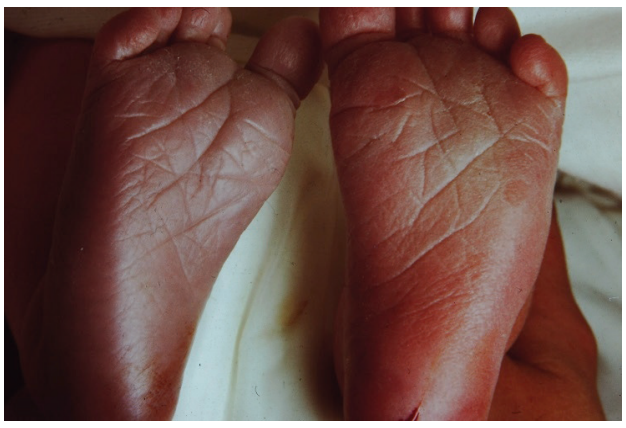

Fig 4.
The feet of the late clamped infant whose haematocrit findings are shown in Fig. 3 at the age of 1 hour. The foot on the right has been gently massaged for two minutes prior to heel puncture.

I should also mention that prior to heel prick the circulation in the baby's heel had always been improved by gentle massage for a timed two minute period (Fig 4).

In retrospect, I was fortunate in having to undertake this fairly routine work myself as it permitted me to make the following simple observations on which this paper is based.

OBSERVATION 1

That infants with very high haematocrits (over 70-80%) often developed blue stockings and gloves indicating a poor peripheral circulation and micro-circulatory stasis (Fig 4).

OBSERVATION 2

That while the blood obtained by heel prick following early cord clamping flowed rapidly into the capillary tube, it did so with much less facility among the late clamped infants, especially when their haematocrits had risen to 70-80% or more. Indeed, with haematocrits over 85% it often became impossible to attract the blood to flow into the capillary tube, presumably because its viscosity had become too great.

OBSERVATION 3

That the plasma in the centrifuge capillary tubes was often observed to be pink when the haematocrit was over 70-75%
(Fig 3) indicating the presence of gross haemolysis with a plasma haemoglobin concentration of 200mg% or more[4]. In summary, no haemolysis was observed in any venous sample but was present in twenty-three (19%) of the 122 heel capillary samples. All came from late clamped infants from the first day of life. There was a strong positive correlation with the height of the haematocrit (Fig 5):

Haematocrit	Haemolysis
< 60%	Nil
60-69%	2.3%
70-79%	38%
Over 80%	92%

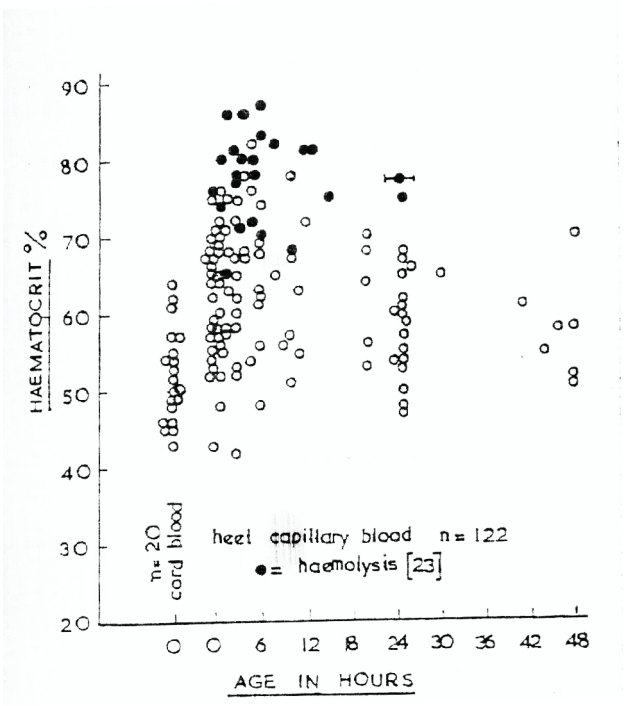

Fig 5.
Haematocrit values (n=l22) from the cord clamping RCT described in the text over the first 48 hours. The dark circles indicate the presence of haemolysis in the supernatant plasma.

MICROCIRCULATORY HAEMOLYSIS

Factors favouring:

Raised haematocrit
Circulatory stasis
Fall in local: - temperature
- blood glucose
- blood oxygen
- pH
Increased blood viscosity
Reduced RBC deformability
RBC sequestration/sludging
Mechanical deformation of RBC

Table 1:
Factors favouring microcirculatory haemolysis (RBC = red blood cells).

OBSERVATION 4

That infants that were or had been polycythaemic frequently developed significant neonatal jaundice and indeed, that there was a strong positive correlation between the degree of polycythaemia and the depth of jaundice.

This observation was confirmed in a large study undertaken at Southmead Hospital, 1970-1973. For example in this study there were 28 infants whose haematocrits rose over 77%. They all received a haemodilution exchange transfusion. Yet in spite of this treatment the serum bilirubin levels of 10 (36%) of these infants rose above 220mmol/l [5].
This study also threw light on the mechanism by which polycythaemia might lead to microcirculatory stasis, red cell damage and haemolysis (Table 1 and Figure 6).

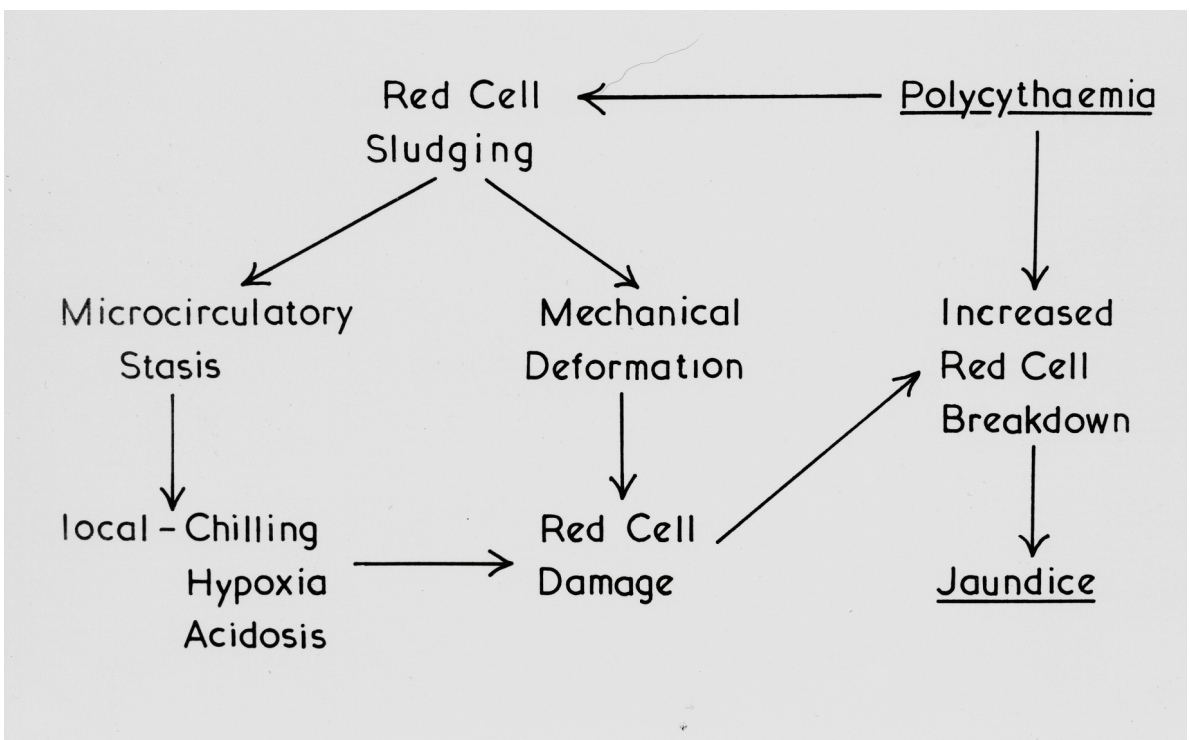

Fig 6.
Diagram to indicate the mechanism by which polycythaemia may lead to micro-circulatory haemolysis and jaundice.

West of England Medical Journal

Formerly Bristol Medico-Chirurgical Journal

The e-journal of the
Bristol Medico-Chirurgical Society

Neonatal polycythaemia, blood viscosity, microcirculatory haemolysis and jaundice WEMJ Volume 116 No.3 Article 1 September 2017

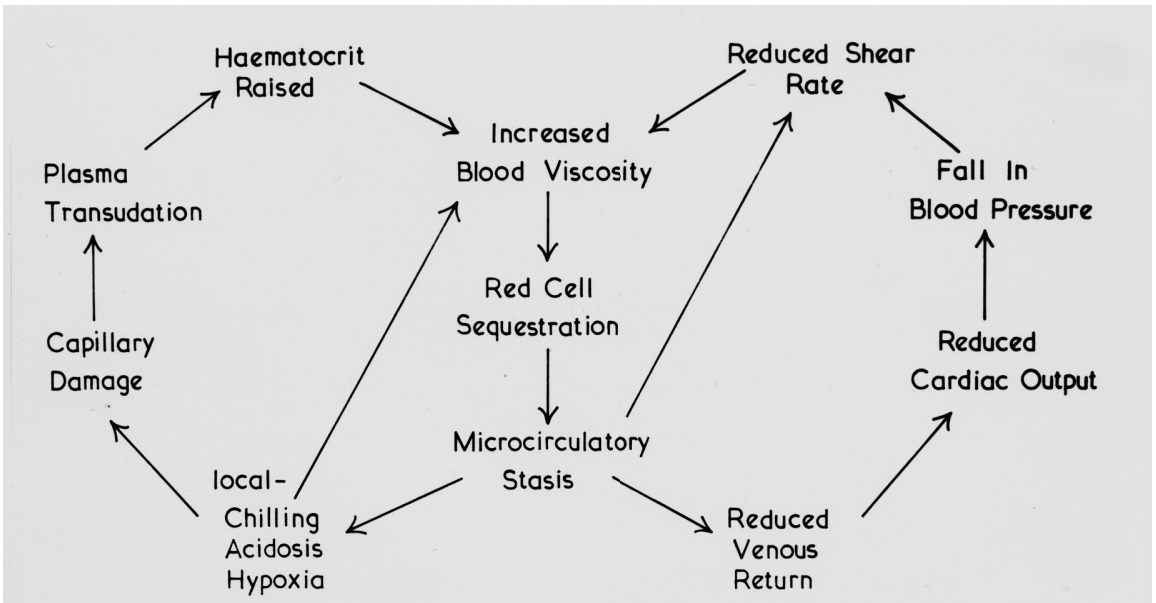

Fig 7.
Diagram showing mechanisms whereby polycythaemia and increased blood viscosity may lead to micro-circulatory stasis.

Studies on blood viscosity at this time undertaken with my colleague, John Ellison, revealed the importance of a falling blood pressure and reduced shear rate in encouraging microcirculatory stasis (Fig 7)[5].

While the jaundice associated with neonatal polycythaemia is commonly attributed just to the elevated red cell mass increasing the bilirubin load to the liver[6], my studies suggested that another and perhaps more important factor might be raised blood viscosity and micro-circulatory stasis leading to red cell deformation and haemolysis.

My observations on microcirculatory stasis were confined to the peripheral circulation in the baby's limbs, it would, however, be wrong not to consider the possibility that the same phenomenon might also affect internal organs especially in areas where the blood pressure and shear rate might be low. This might, in particular, apply to the newborn baby's pulmonary circulation soon after birth in the presence of a patent ductus arteriosis. Pathologists have long recognised that the lungs of premature infants dying from respiratory distress syndrome typically had the colour and consistency of liver. They also sank in water. The histology of such lungs certainly suggests massive microcirculatory stasis (Fig 8).

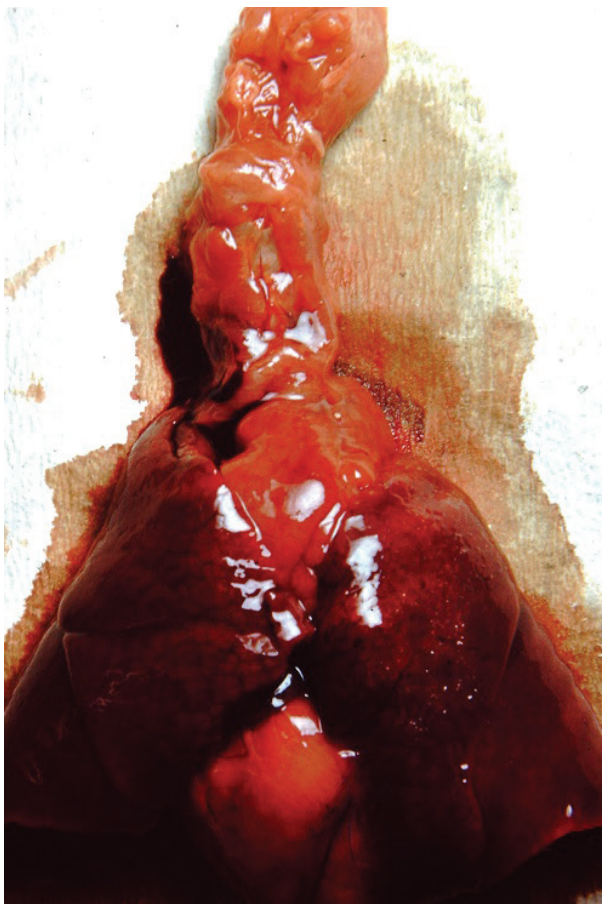

Fig 8.
At post-mortem: The lungs and heart of a prematurely born infant that died of respiratory distress syndrome on the second day of life. Note the blue/black and firm appearance of the lungs. They sank in water.

CONCLUSION

In summary, delayed clamping of the umbilical cord may lead to severe neonatal polycythaemia soon after birth due to the placental transfusion and the resulting postnatal plasma shift. Severe polycythaemia and raised blood viscosity may lead to microcirculatory stasis, to haemolysis and to neonatal jaundice.
Microcirculatory stasis acting internally may lead to organ failure. It may well contribute to pulmonary failure in the respiratory distress syndrome of the premature infant. In which case the umbilical cord should in future be so managed as to avoid an over-large placental transfusion[7].

REFERENCES

1. Dunn, P.M. Neonatal polycythaemia, microcirculatory haemolysis and jaundice. (Ab). Early Human Development, 1991; 26, 231-232.
2. Dunn, P.M. The changing haematocrit on the first day of life. The Neonatal Society, May 1965, Bristol. In: P.M. Dunn. Lectures, Vol I, (2), 1-7. Held by the University of Bristol Medical Library, Bristol.
3. Dunn, P.M. Polycythaemia of the newborn: cause and effect. Printed privately. Baylor University, Texas, 1967, pp.1-7. Also in: P.M. Dunn. Lectures, Vol I, (10), 1-27. Held by the University of Bristol Medical Library, Bristol.
4. Michaelsson, M. and Sjolin, S. Acta Paediat. Scand., 1965; 54, 325-330.
5. Dunn, P.M. Neonatal polycythemia. Neonatal Symposium, Bristol, September, 1973. In: P.M. Dunn. Lectures, Vol III, (43), 1-17. Held by the University of Bristol Medical Library, Bristol.
6. Glader, B. (1977) In: Diseases of the Newborn, 4th Edn., p.624. Editors: A.J. Schaffer and M.E. Avery. W.B. Saunders, Philadelphia.
7. Dunn, P.M. Managing the umbilical cord. Infant, 2009; 5, 73.