2

The Effect of Intrauterine Development and Nutritional Status on Perinatal, Intrauterine and Neonatal Mortality: The MDN System

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1. Introduction

Obstetricians and neonatologists have since long made efforts to estimate precisely the life chances of neonates soon after their birth, even in the delivery room. The objective is twofold: to diagnose possible diseases and recognise and differentiate the neonates who are highly endangered because of the deficiencies and disorders of their bodily development.

The most common method is still in use: by measuring the bodyweights of neonates, one can immediately differentiate those whose weights are below 2,500 grams, and who are regarded as being the most endangered newborns. Recently, however, specialists normally differentiate between neonates of body weight below 1,500 grams, those less than 1,000 grams and those who weigh less than 500 grams at birth. At the same time, we have learned that body weight alone is not a reliable parameter to estimate the life chances of a neonate (Macferlene et al., 1980, WHO, 1961, 1970, Wilcox & Russel, 1983, 1990). This is true for a series of reasons: (1) body weight depends on many factors; (2) each weight group is extremely heterogeneous when gestational age, body length and nutritional status (nourishment) are considered (Berkő, 1992, Berkő & Joubert, 2006, 2009, Zadik et al., 2003), however, scientific research needs homogeneous groups to study; (3) since the average birth weights of neonate populations differ greatly by country and race (Meredith, 1970), there is no practical chance to develop uniform weight criteria to be applicable in each country.

Another option is to determine the gestational ages of neonates in order to differentiate highly endangered or preterm babies. As the survival chance correlates with gestational age rather than with birthweight, in 1961 WHO declared that not a birth weight below 2500 grams, but neonates born before the 37th week have to be considered as premature (WHO, 1961).

Lubchenco was the first to recognise that body weight and gestational age have to be considered simultaneously in order to determine the bodily development of a neonate (Lubchenco et al., 1963). On the basis of the birth standards developed by Battaglia & Lubchenco (1967), it was recommended that newborns below the 10th weight percentile, or

SGA (small for gestational age), were qualified as being highly endangered. Later on, SGA neonates were referred to as having intrauterine growth retardation (IUGR), because many newborns in the weight group under the 10^{th} weight percentile were found to have retardation syndrome.

However, it was revealed later that the clinical picture of retardation is not a uniform syndrome, taking into account its etiology, clinical picture and prognosis (Bakketeig, 1998, Battaglia and Lubchenco, 1967, Deorari et al., 2001, Doszpod, 2000, Golde, 1989, Gruenwald, 1963, 1966, Henriksen, 1999, Kurjak et al., 1978, Kramer et al., 1990, Lin et al., 1991, Lin, 1998, Rosso & Winick, 1974, Senterre, 1989, Wollmann, 1998). As a basic requirement, one has to be able to differentiate between proportionally and disproportionally retarded newborn babies. One can only do that if gestational age and birth weight body length is also considered (Abernathy et al., 1996, Golde, 1989, Kramer et al., 1990, Miller & Hassanein, 1971). Rohrer's Ponderal Index (Hassanein, 1971, Rohrer, 1961) was introduced for this purpose, but it was not commonly used, because the database to calculate the index was limited and the proposed mathematical formula [(gram/cm^3)x100] was not popular. Nevertheless, more and more authors underline the need for the consideration of nutritional status.

Recent scientific results confirm the recognition that the development and nutritional statuses of foetuses and neonates have a major impact on their viability, their intrauterineand neonatal morbidity (Kadi and Gardosi, 2004, Shrimpton, 2003), as well as on their morbidity in adulthood (Barker et al., 1993, Goldfrey & Barker, 2000, Gyenis et al., 2004, Henriksen, 1999, Joubert & Gyenis, 2003, Osmond & Barker, 2000). It also has been proven that development and nutritional status at birth influence the growth rate, bodily development, and the intellectual faculties of a child up until 18 years of age (Joubert & Gyenis, 2003).

The authors firmly believe that more accurate estimations of the survival chances and the degree of endangeredness of neonates can be achieved if the three important factors are simultaneously considered: (i) maturity (gestational age); (ii) bodily development (weight and length standard positions determined on the basis of appropriate weight and length standards); (iii) nutritional status depending upon the relative weight and length development. However, the question is how to consider all of these factors at the same time, and more importantly, how to differentiate less endangered and highly endangered neonate groups identified in this complex system of classification. The authors developed a new method to achieve this.

In the present study the authors describe their novel method, the MDN system (MDN: Maturity, Development, Nutritional status) (Berkő, 1992, Berkő & Joubert, 2006, 2009) and its application:

- to determine the nutritional status of a neonate on the basis of its gestational age, length and weight delopment considered simultaneously;
- to differentiate the most viable and the most endangered neonates on the basis of their development and nutritional status;
- to demonstrate the influence of a neonate's bodily development and nutritional status by intrauterine, neonatal and perinatal mortality rate.

- to identify and distinguish those retarded neonates who are likely to need growth hormone treatment in the future.

2. Method – The MDN system

The MDN system, integrating four important birth parameters, offers a method to decide to what extent a neonate is endangered on the basis of its bodily development and nutritional status. The four parameters: sex, gestational age, birth weight and birth length.

2.1 The determination of weight and length standard positions

The weight and length development of a newborn is determined on the basis of its sex, gestational age, body mass and length at birth. To do this, however, sex-specific national weight and length standards of reference value are needed. In Hungary, Joubert prepared such standards on the basis of the birth data of babies born in this country between 1990 and 1996 (799,688 neonates) (Joubert, 2000). As is the case with other commonly known standards, Joubert's standards apply 7 percentile curves (percentiles 3, 10, 25, 50, 75, 90 and 97) to divide the entire weight and length ranges into 8 weight zones and 8 length zones. The field under percentile curve 3 forms zone 1; zone 2 is made by the area between percentile curves 3 and 10, while the area above percentile curve 97 gives zone 8 (as shown in Tables 1-4).

Zones	Percen-tiles	Gestational weeks																								Percen-tiles
		20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	
8																										
	97	705	775	845	925	1019	1129	1269	1425	1615	1825	2055	2285	2545	2787	3048	3325	3579	3819	4018	4193	4349	4495	4595	4627	97
7																										
	90	595	665	735	815	895	995	1119	1259	1435	1616	1828	2055	2277	2508	2755	3008	3276	3525	3729	3909	4075	4195	4295	4328	90
6																										
	75	525	585	645	718	795	888	995	1128	1295	1475	1649	1845	2048	2259	2488	2725	2976	3238	3458	3655	3795	3895	3955	3979	75
5																										
	50	455	501	555	621	705	781	881	1005	1155	1311	1481	1659	1851	2045	2255	2475	2721	2949	3161	3349	3495	3608	3655	3671	50
4																										
	25	385	422	475	533	595	685	782	895	1015	1152	1305	1455	1615	1805	2005	2211	2425	2663	2875	3055	3213	3305	3341	3352	25
3																										
	10	311	351	395	455	515	595	683	775	881	995	1123	1253	1395	1561	1745	1935	2164	2395	2623	2805	2925	3005	3035	3021	10
2																										
	3	245	275	315	361	422	482	561	643	725	833	935	1051	1182	1323	1493	1671	1872	2105	2322	2524	2672	2754	2762	2735	3
1																										

Table 1. Weight standards for the Hungarian male neonates born between 1990 and 1996 (grames)

Zones	Percen-tiles	Gestational weeks																								Percen-tiles
		20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	
8																										
	97	36.9	39.1	41.1	42.9	44.6	46.2	47.6	49.1	50.5	51.6	52.7	53.6	54.5	55.3	56.2	56.9	57.5	58.1	58.5	58.8	59.1	59.2	59.3	59.4	97
7																										
	90	34.1	36.2	38.3	40.2	41.9	43.5	44.9	46.5	47.8	49.1	50.3	51.3	52.3	53.3	54.2	54.9	55.7	56.4	56.9	57.4	57.6	57.8	57.9	57.9	90
6																										
	75	31.8	33.9	35.8	37.7	39.4	40.9	42.5	43.9	45.3	46.6	47.9	49.1	50.2	51.3	52.3	53.1	53.8	54.5	55.1	55.4	55.6	55.8	55.9	55.9	75
5																										
	50	29.5	31.4	33.3	35.1	36.9	38.6	40.1	41.6	42.9	44.3	45.7	46.9	48.1	49.3	50.4	51.3	52.1	52.7	53.2	53.5	53.7	53.9	53.9	54.1	50
4																										
	25	27.1	29.1	30.8	32.7	34.3	36.1	37.6	39.1	40.7	42.1	43.5	44.7	46.1	47.2	48.4	49.5	50.3	50.9	51.4	51.8	52.1	52.2	52.2	52.3	25
3																										
	10	24.4	26.5	28.3	30.2	31.9	33.5	35.1	36.7	38.3	39.9	41.3	42.7	44.1	45.4	46.5	47.8	48.6	49.3	49.9	50.2	50.4	50.4	50.5	50.5	10
2																										
	3	21.6	23.4	25.2	27.2	28.9	30.7	32.3	33.9	35.4	36.9	38.5	40.1	41.8	43.2	44.8	46.1	47.1	47.8	48.2	48.6	48.8	48.9	48.9	49.1	3
1																										

Table 2. Length standards for the Hungarian male neonates born between 1990 and 1996 (centimetres)

Zones	Percentiles	Gestational weeks																								Percentiles
		20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	
8																										
	97	675	725	801	895	995	1118	1269	1438	1638	1845	2055	2295	2545	2775	3015	3239	3466	3669	3855	4025	4176	4315	4368	4355	**97**
7																										
	90	595	635	689	765	849	965	1096	1245	1417	1605	1796	2005	2235	2455	2685	2917	3155	3375	3568	3747	3898	4005	4055	4049	**90**
6																										
	75	529	555	601	668	755	855	968	1097	1255	1425	1615	1805	2018	2225	2438	2655	2885	3098	3296	3475	3619	3725	3775	3798	**75**
5																										
	50	461	479	521	582	655	749	852	967	1101	1255	1425	1602	1803	1998	2201	2402	2617	2835	3035	3202	3329	3415	3475	3497	**50**
4																										
	25	395	415	451	501	573	651	751	855	975	1105	1245	1402	1581	1765	1952	2145	2355	2565	2773	2945	3075	3161	3202	3205	**25**
3																										
	10	335	352	382	425	481	562	643	735	843	953	1072	1201	1355	1525	1701	1891	2103	2325	2525	2703	2835	2912	2943	2951	**10**
2																										
	3	282	295	323	355	405	465	531	614	702	791	885	1003	1132	1283	1455	1645	1845	2052	2255	2455	2614	2701	2725	2732	**3**
1																										

Table 3. Weight standards for the Hungarian female neonates born between 1990 and 1996 (grames)

Zones	Percentiles	Gestational weeks																								Percentiles
		20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	
8																										
	97	37.5	39.3	41.3	43.1	44.8	46.4	47.9	49.3	50.5	51.7	52.7	53.5	54.5	55.2	55.9	56.5	57.1	57.5	57.8	58.1	58.3	58.4	58.5	58.6	**97**
7																										
	90	34.8	36.5	38.5	40.2	41.8	43.5	45.2	46.7	48.1	49.2	50.3	51.3	52.2	53.1	53.7	54.4	55.1	55.6	56.1	56.4	56.6	56.8	56.9	56.9	**90**
6																										
	75	32.1	33.9	35.6	37.3	39.1	40.8	42.5	43.9	45.4	46.8	47.9	49.1	50.1	51.1	51.9	52.7	53.3	53.9	54.4	54.7	54.9	55.2	55.3	55.4	**75**
5																										
	50	28.8	30.8	32.9	34.7	36.5	38.1	39.6	41.1	42.6	43.9	45.3	46.5	47.7	48.7	49.7	50.5	51.3	51.9	52.4	52.9	53.2	53.4	53.5	53.5	**50**
4																										
	25	26.1	28.1	30.1	32.1	33.9	35.8	37.5	39.1	40.4	41.9	43.2	44.4	45.7	46.9	47.9	48.9	49.7	50.3	50.8	51.1	51.3	51.5	51.6	51.6	**25**
3																										
	10	23.1	25.3	27.2	29.3	31.3	33.1	34.9	36.6	38.1	39.6	41.1	42.4	43.8	44.9	46.2	47.2	47.9	48.5	49.1	49.4	49.6	49.8	49.9	49.9	**10**
2																										
	3	20.1	22.1	24.1	26.1	28.1	30.1	31.9	33.7	35.3	36.8	38.3	39.8	41.2	42.6	43.9	45.2	46.2	46.8	47.4	47.7	47.9	48.1	48.2	48.3	**3**
1																										

Table 4. Length standards for Hungarian female neonates born between 1990 and 1996 (centimetres)

By using tabulated standards or software designed specifically for the purpose, knowing the gestational age one can easily determine the weight zone (W) and length zone (L) of a newborn baby on the basis of its weight and length at birth. Any neonate can be described with the letters (W and L) and numbers (1-8) of its weight and length zones. For example, if the birth weight of a newborn is in weight zone 6, i.e., between weight percentile curves 75 and 90, and its length is in length zone 2, i.e., between percentile curves 3 and 10, then the standard positions of this baby are W6 and L2.

2.2 Description of the nutritional status

To characterize and decribe the nutritional status of the newborn (N) one should know the relation of his weight standard position (W) to his own length standard position (L). The authors prepared a matrix comprising eight horizontal lines for the weight standard zones and eight columns for the length standard zones, which seems a useful tool to determine the nutritional status of neonates. This 64-cell matrix is referred to as the MDN matrix (see Figure 1, where the neonate mentioned earlier as [W6, L2] is positioned in the grey cell). Any newborn can be positioned in this table, no matter what weight or length zone it belongs to. Each cell is identified by the letter and number of the weight zone and of the length zone, in the intersection of which the cell is located in the matrix.

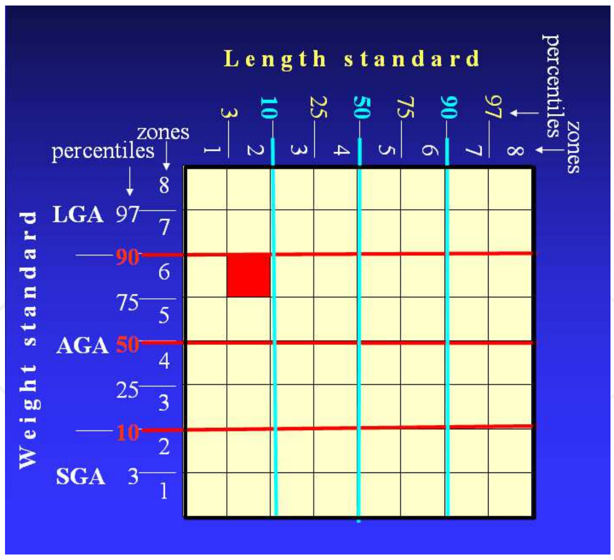

Fig. 1. MDN matrix for the simultaneous representation of weight and length standard positions of neonates**.** Neonates in cell W6-L2 belong to weight standard zone 6 (between percentile curves 90 and 97) and to length standard zone 2 (between percentile curves 3 and 10).

In order to describe nutritional status (N) of a neonate, one has to know its weight standard position (weight zone number = W) and length standard position (length zone number = L). The calculation of the nutritional index, or nourishment status: N = W – L. If the number of the weight zone is higher than that of the length zone, then N will be a positive number, which means that the baby is born with a relative overweight (overnourished). When N is a negative number, the baby is relatively underweight for its length. Using the example above, (W6,L2) works out to N=+4, or an overnourished baby.

Figure 2 demonstrates the nutritional status (N value) of neonates in each cell of the 64-cell MDN matrix. The N value, representing nutritional status as rated according to the

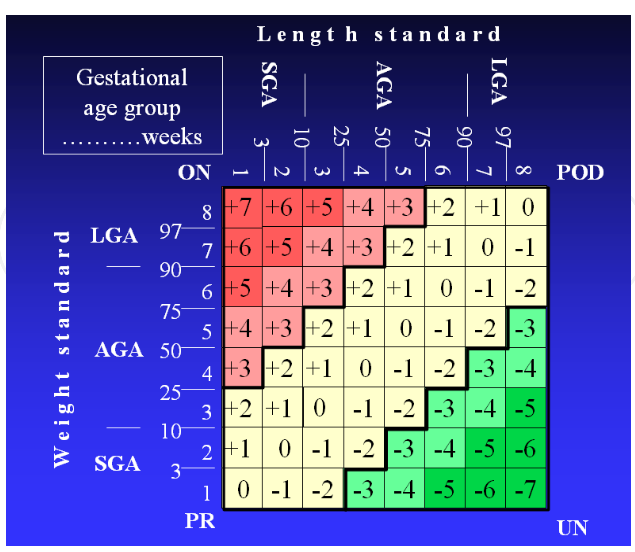

Fig. 2. The weight and length standard positions (W and L) and N values (W-L) of neonates with different nutritional statuses in the MDN matrix**.** The corners of the MDN matrix: PR (proportionally retarded), POD (proportionally overdeveloped), ON (overnourished), UN (undernourished).

matrix, can range from +7 to –7. Obviously, extremely overnourished neonates are positioned in the cells marked +5,+6,+7, while extremely undernourished ones will be positioned in the cells marked -5,-6,-7. In an ideal case, a neonate is positioned in the weight zone and length zone having identical numbers when its N value = 0. Neonates with N = 0, N = +1 or +2 and those with N = -1 or -2 are regarded as being normally (or proportionally) nourished.

For better understanding, the four corners of the MDN matrix are marked with letters to indicate the typical differences in the development and nutritional statuses of neonates positioned in the cells nearest to the corners of the matrix. Abbreviations: PR = proportionally retarded, POD = proportionally overdeveloped, ON = overnourished, UN = under-nourished (or DPR, that is disproportionally retarded).

2.3 Classification of neonates according to the degree of nourishment

On an MDN matrix the gestational age-group should always indicate the appropriate data from the standards tables. Figure 3 and Table 5 demonstrate the most typical groups of newborns according to their nourishment. The figure also demonstrates the incidence rates of neonates with specific development and nutritional status in the neonate population born in Hungary between 1997 and 2003 (680,947 newborn babies as recorded by the Hungarian Statistical Office). About 90.6% of the Hungarian newborns are averagely nourished. Of these, 25.8% were at an "absolutely normal" level of development and nourishment. The incidence of the undernourished group (UN, which we consider to be disproportionally retarded) is 4.5%. The ratio of overnourishment (ON) is 4.9%. The percentage of proportionally retarded (PR) neonates who are likely to need growth hormone therapy is 4.5%. In the Figure 3, below the 10th percentile – in the weight zone W1-2 - a mixed group of retarded is to be found among the proportionally and disproportionally retarded neonates (Berkő, 1996). Looking at the figure it is easy to recognize that the so-called SGA-born infants form a highly heterogeneous group. This fact implies that it is wrong to consider the SGA group as a whole to be the potential ones to receive growth hormone treatment, since

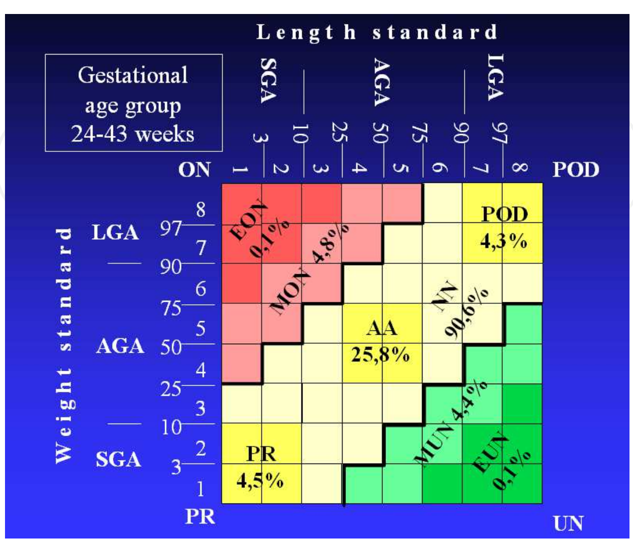

Fig. 3. The classification (and percentage distribution) of Hungarian neonates born between 1997 and 2003 by bodily development and nourishment.

only growth of the proportionally retarded or possibly the mixed group of retarded neonates (MR) will lag behind the average.

Table 5 shows how to define and separate the most characteristic groups of neonates according to their differing nutritional status.

Nourishment	Abbreviations	Position on the MDN table	Prevalence %
Overnourished	ON	N = +3 - +7	4.9
extremely overnourished	EON	N = +5, +6, +7	0.1
moderately overnourished	MON	N = +3, +4	4.8
Normally nourished	NN	N = -2 - +2	90.6
proportionally overdeveloped	POD	W7-8, L7-8	4.3
absolute average	AA	W 4-5 L4-5	25.8
proportionally retarded	PR	W1-2 L1-2	4.5
Undernourished (disproportionally retarded, DPR)	UN (DPR)	N = -3 - -7	4.5
moderately undernourished	MUN	N = -3, -4	4.4
extremely undernourished	EUN	N = -5, -6, -7	0.1

Table 5. Most typical groups of newborns according to their nourishment

2.4 The numerical representation of neonates by their maturity, weight and length with the help of the MDN index

As explained earlier, the MDN method is a tool to describe the maturity, bodily development and nutritional status of any neonate numerically. The *MDN index = GA / W / L / N,* where GA is gestational age in weeks; W is a number that demonstrates which zone the numeric weight score belongs to (1 to 8); L is the corresponding score of the body-length standard (1 to 8); N=W-L, the score of the nutritional status. If N is a positive number, this means that the baby is born with a relative overweight (overnourished, ON). When N is a negative number, the baby is relatively underweight for its length. The group of UN neonates can be characterized as disproportionally retarded (DPR)._Examples: (a) MDN index is GA=38 / W= 6 / L= 2 / N= +4; (b) MDN index is GA=38 / W= 2 / L= 6 / N= -4 (Berkő and Joubert, 2006, 2009).

3. The effect of bodily development and nutritional status on perinatal mortality

By processing the birth data of the entire neonate population, gestational age 24-43 weeks, born in Hungary in the years 1997 to 2003, the authors studied the perinatal mortality rate of the neonates in each cell of the MDN matrix (Figure 4). The four cells in the centre of the table represent the neonates considered an *absolute average* (AA) or etalon group on the basis of their weight and length.

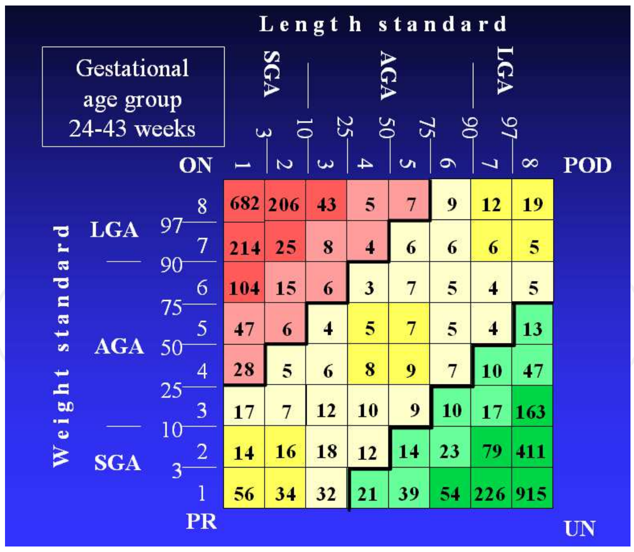

Fig. 4. Perinatal mortality rates (‰) of the entire Hungarian neonate population (gestational age 24-43 weeks) born between 1997 and 2003, as represented by the cells of the MDN matrix.

Relying on the birth data of neonates born between 1997 and 2003, the authors find *perinatal mortality rate to be 8.9‰* in Hungary in that period of time. For comparison, this rate in the absolute average group, which is necessary to determine for comparative studies, was 7‰ in the same period of time. The highlighted sectors of the MDN matrix in Figure 5 represent the most endangered neonate groups.

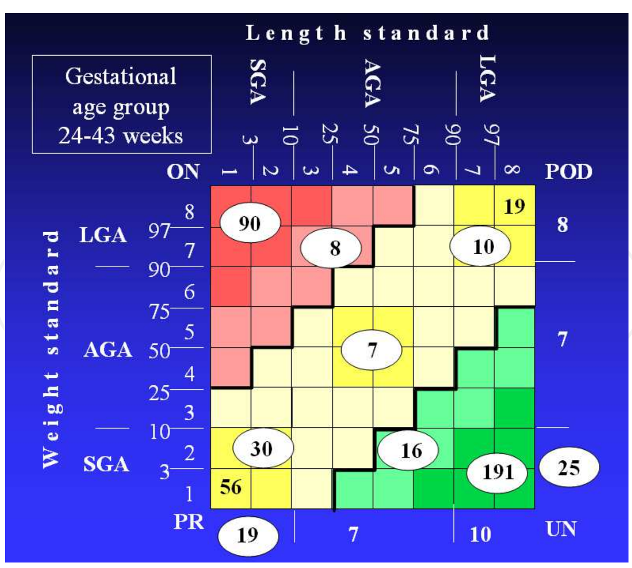

Fig. 5. Perinatal mortality rates (‰) in the major groups of the Hungarian neonate population (gestational age 24-43 weeks) born between 1997 and 2003, which are regarded as being the most endangered groups on the basis of bodily development and nutritional status (as represented in the major sectors of the MDN table)

3.1 The major groups of highly endangered foetuses and neonates with the help of the MDN matrix

Undernourished (UN) group. These babies were born with insufficient weight and often show the syndrome of classic **disproportional retardation.** The perinatal mortality rate is rather high, 21‰ in the large group of undernourished neonates. The group comprises the moderately undernourished subgroup with a PM rate of merely 16‰. The cells creating the triangle of extremely undernourished neonates (EUN) in the UN corner of the table have a conspicuously high PM rate of 191‰. The MDN table clearly shows that disproportional retardation, which causes a high mortality rate, can be found not only among the neonates under weight percentile 10, but also among those over weight percentile 10, as two-thirds of the investigated cases show.

Overnourished (ON) group**.** The PM rate is 10‰ in the overnourished group**.** This group includes the moderately overnourished subgroup where the PM rate is only 8‰. The PM rate is 90‰ in the triangle of the extremely overnourished group (EON) in the ON corner of the MDN Table.

Proportionally retarded (PR) group. Proportionally retarded babies are positioned in the four bottom left cells (in the PR corner) giving the field bordered by weight percentile 10 and length percentile 10. The PM rate in this group is 30‰. However, the smallest disproportionally retarded neonates, being under percentile 3 by both weight and length (EPR), have an even higher PM rate of 56‰.

Proportionally overdeveloped group. The group of extremely proportionally overdeveloped (EOD**)** or giant babies should not be overlooked. They are positioned in the POD corner of the table, with both their weight and length in the 8th percentile zone. They are also highly endangered, as is shown by the 19‰ PM rate of this cell.

Perinatal mortality in the heterogeneous SGA group. PM rate in the weight group under the 10th percentile (heterogeneous SGA by length and nutritional status) is 25‰ (in the AGA group it is 7‰, and 8‰ in the LGA group, which is over the 90th percentile). A very high PM rate of 43‰ is found in the weight group under the 3rd percentile.

3.2 The effect of bodily development and nutritional status on perinatal mortality in the groups of Hungarian premature and mature infants

By comparing the perinatal mortality (PM) of Hungarian preterm and full-term neonates, using the data given in Figure 6, we can conclude the following: (1) absolutely averagely developed and nourished (AA) preterm infant mortality is 28 times as high as that of the full-term AA group, and (2) independently of gestational age disproportional retardation (DPR), extreme overnourishment (EON) and proportional retardation (PR) significantly enhance the perinatal mortality risk of preterms born in the 24th-36th gestational week compared to that of full-term neonates (37th-42nd gestational week).

4. Criticism of the "perinatal mortality" indicator

Perinatal mortality (PM) is one of the most important parameters of public health indicator data. It describes the incidence of late (24 weeks or older) fetal intrauterine death, plus the perinatal (1st to 7th day) death incidence of the live-born fetuses of the population studied. In standard practice, this is the only indicator with which we can draw conclusions on prenatal care, delivery room care and neonatal care quality level. I believe that now is the time for us to realize that the PM is not really suitable for this purpose (Berkő, 2006). Why?

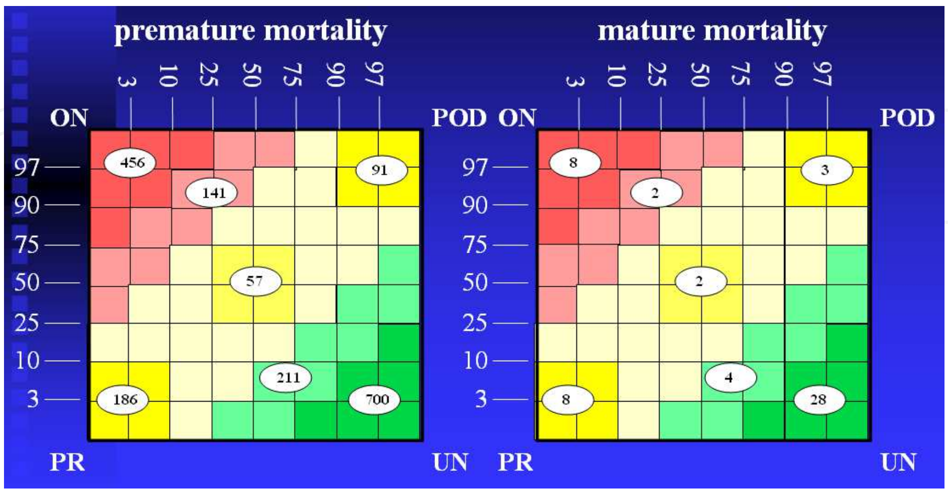

Fig. 6. Comparison of perinatal mortality of the premature and mature Hungarian infants with the help of the MDN matrix.

4.1 Intrauterine and neonatal mortality rate is also important to know

Morbidity and mortality parameters are useful when they also reveal the cause of the particular disease or death. PM is not suitable for this. In Hungary, perinatal mortality in 2007 (in two counties) was 11.1‰. But while in one of the three counties, County A, the intrauterine fetal mortality incidence was 3.6‰ and the neonate mortality 7.5‰, County B's situation was vice-versa, with intrauterine death at 7.3‰ and a perinatal (1st to 7th day of life) mortality rate of 3.8‰. It is quite obvious that there are problems with neonatal care in County A, while County B suffers from inappropriate prenatal care. If we only possess the average information of 11.1‰ perinatal mortality for both counties, there is no mode for recognition of such problems, nor is there any opportunity to set tasks for specific care improvement. Therefore I propose that each case of perinatal mortality rate should be supplemented with the two components of the PM: intrauterine and perinatal mortality.

4.2 Extention of the "perinatal period" concept should be considered!

But there is another problem. The concept of PM along with intrauterine death includes also mortality occurring on Day 1-7 postpartum. This is unacceptable nowadays. Hungary clearly shows that there is no reason for feeling satisfied, since along with declining perinatal mortality (1st-7th day after delivery) a continuous parallel increase of 8th-28th day neonatal mortality has been observed. The explanation for this is that the use of modern medications and breathing support allows us to extend the life of many small prematurely born infants, whom we lose only after the 7th day of their lives. With this in mind, therefore, I propose to introduce the concept of "*extended perinatal mortality*" *(EPM)*, which includes intrauterine deaths (IUM) and live-born infant Day 1-28 mortality (NM).

In view of facts described above, let us graphically represent the perinatal (PM), intrauterine (IU) and neonatal (NM, day 1-28) Hungarian mortality data of 1997-2003 in correlation with bodily development and nutritional status (Figure 7 and Table 6). It is clear to see that growth retardation and overnourishment nearly identically increase the intrauterine and

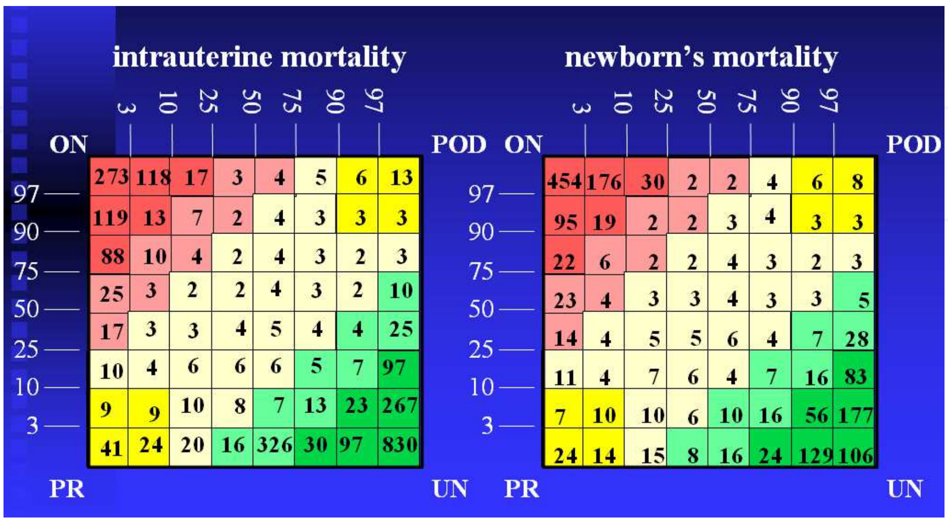

Fig. 7. Comparison of intrauterine and neonate mortality (‰) based on the MDN matrix

Nourishment	**Abbre-viations**	**Perinatal mortality (‰)**	**Intrauterine mortality (‰)**	**Day 1-28 neonatal mortality (‰)**	**Extended perinatal mortality (‰)**
680,947 newborns, 1997-2003		8.9	4.3	5.1	9.4
Overnourished	ON	10	6	5	11
extremely ON	EON	90	51	49	100
moderately ON	MON	8	5	5	10
Normally nourished	NN	9	5	5	10
proportionally overdeveloped	POD	10	6	5	11
absolute average	AA	7	4	4	8
proportionally retarded	PR	30	20	14	34
Undernourished (disproportionally retarded)	UN (DPR)	21	12	12	24
moderately UN	MUN	16	9	10	19
extremely UN	EUN	191	124	78	202
Weight for gestational age					
large	LGA	8	5	8	13
average	AGA	7	4	7	11
small	SGA	25	17	25	42

Table 6. Intrauterine and perinatal (1-28 day) mortality according to the most characteristic development and nutritional groups of newborns

neonatal mortality rate. Is also obvious that following groups are most at risk, in descending order: in greatest danger - the group of extremely undernourished (severe disproportional retardation) (EUN), extremely overnourished (EON), and proportionally retarded (PR), followed by the group of extremely proportionally retarded (EPR). A significantly higher mortality rate can also be observed among the proportionally overdeveloped neonates (POD, respectively EPOD). Figure 7 proves that a significant deviation in physical development and nourishment from the average (i.e., the PR, EON, DPR groups) is of great danger to both foetuses in utero and and neonates (Day 1-28).

5. Conclusion – The practical importance of the MDN system

Relying on the empirical fact that the degree of nourishment and the status of development have a high influence on the life prospects of neonates, the authors developed a method, the MDN system – including an MDN matrix – to study and qualify the nutritional status at birth. The MDN system can be applied when gestational age, birth weight and length are known and when reliable weight and length standards are available for reference.

The MDN index provides an easy and short numerical characterization of every newborn according to its state of maturity, bodily development and nutritional status. This requires only four parameters : MDN index = GA / W / L / N (gestational age, weight, length, nutritional status).

The MDN matrix enables effective separation into groups according to their mortality risk grade, using developmental and physical characteristics and degree of nourishment: the groups describe averagely developed and nourished neonates, those who were born with more or less overweight or weight deficit, as well as proportionally over- and underdeveloped newborns.

Having evaluated nearly 700,000 cases of Hungarian neonate data we have found that significant deviation from average physical development and nourishment - particularly undernourishment (disproportional retardation), extreme overnourishment and proportional retardation – is of great danger to both foetuses in utero and live-born neonates. This is valid for preterm and full-term foetuses, and for neonates as well.

As seen in Figure 2, undernourished (N = -3, -4, -5), or disproportionally-retarded, newborns can occur also above weight zone W2, above the 10^{th} percentile. This is why the authors do not agree with the definition of retardation as those under the 10^{th} percentile. Therefore, the authors offer a novel method to identify and differentiate proportionally retarded, disproportionally retarded and mixed type retarded newborns below the 10^{th} weight percentile, as well as disproportionally retarded newborns over the 10^{th} weight percentile. We should however mention that the MDN system is not suitable for determination of the genetically affected among the proportionally small newborns or for those who stayed proportionally small due to some pathological pregnancy reasons.

Our investigation found that if bodily development and nutrition significantly differ from the average, then the fetus has a significantly higher chance of intrauterine death, and this is also true for the newborn in the 1st-28th day of life. In this respect, the group of extremely disproportionally retarded is most at risk, followed by the extremely overnourished and the proportionally retarded, especially when extremely proportionally retarded. However, the proportionally overdeveloped fetuses and newborns are highly vulnerable as well.

In addition, the authors propose a definition expansion of the worldwide used concept of "perinatal mortality" concept. They further recommend the implementation of an "extended perinatal mortality" (EPM) definition along with obligatory differentiation of intrauterine mortality (IUM), and neonatal mortality of the live-born respectively (NM, 1st-28th day). This will allow weaknesses and strengths in prepartum, intrapartum and postpartum medical care to be identified.

The MDN system as a method can be applied in any country. Ideally, the development of neonates born in the studied country should be determined first according to country-specific (or preferably race-specific) weight and length percentile standards. Then, each neonate will be rated by and positioned in its nation-specific MDN matrix. The morbidity and mortality rates of different national neonate groups with equivalent positions in their national MDN matrices can be compared with this method. This also makes possible the comparison of neonatal morbidity and mortality data of countries, even if average birth weights are significantly different. The MDN system offers a tool to make more accurate and more reliable national and international comparative studies.

Such comparative studies have not really been realisable yet. So far, only the mortality of newborns with equal bodyweight has been compared, which makes little sense. Consider: is it possible to compare the chances of, say, a newborn in Papua New Guinea weighing 2, 400 grams with those of a newborn of 2,400 grams born in Norway? The body weight of 2,400 grams for a Papua New Guinea child corresponds to the national average birth standard, while its Norwegian counterpart corresponds to the weight of a premature infant, since in Norway the average full-term weight is 3,450 grams. A comparison like this obviously makes no sense. The implementation of the MDN system, however, solves this problem. If all countries would prepare national new-born weight and length standards, and each of the country's newborns would be placed in the locally relevant MDN matrix, national mortality and morbidity data of the same MDN population variations of newborns could be realistically compared. Such comparative studies would provide a more solid basis for scientific conclusions in comparison to those, made today based only on comparative weight tests. This is the supreme virtue of the MDN system, as this offers a tool to perform accurate national and international comparative studies.

The MDN system has another important area of application. It allows the prompt and accurate identification of those newborns for whom systematic follow-up measurements and growth hormone therapy treatment is likely to be necessary in the future. By positioning newborns in a corresponding area of the MDN matrix in the delivery room an immediate in situ distinction of proportional and mixed type retardation is possible. This is important because the mixed retarded group is the one with a later increased risk of certain diseases (hypertension, diabetes mellitus, etc). and therefore requires intensified observation. It is of great importance to register and follow up on the proportionally retarded and those with mixed retardation, for as a consequence they are most likely to lag behind the average growth rate in the future, and possibly require growth hormone treatment at the ages of 2-4**.**

In recent years enhanced interest in the MDN system gives us reason to hope that we have succeeded in enpowering the science and systematics of perinatology and pediatrics with a multifunctional, practical diagnostic tool.

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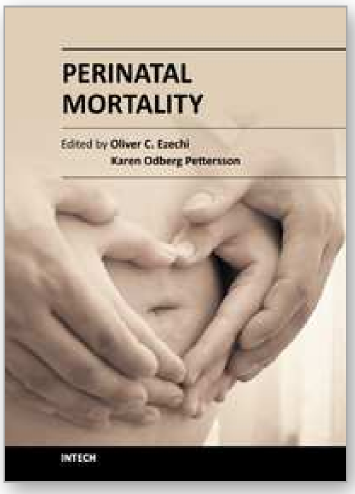

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This book is a compendium of important topics related to perinatal mortality. It has been written for anyone who is interested in perinatal medicine and wishes to be part of the global strategy for prevention and control of perinatal mortality. It covers variety of subjects using simple language that can easily be understood by most health workers and those interested in quality health care. Postgraduate students in midwifery, obstetrics and paediatrics will also find it a very useful companion.