PERSISTENT IMPAIRMENT OF CEREBRAL CORTICES DUE TO PROTEIN-ENERGY MALNUTRITION (PEM) 
Anatomical, Histological, and Physiological Perspectives

Viskasari P Kalanjati
Department of Anatomy & Histology
Airlangga University School of Medicine

ABSTRACT

Brain development is a complex matter related with the multifactorial conditions. A certain period of the brain growth, when the brain is sensitive mostly to many external disturbing factors including protein-energy malnutrition (PEM), could be demonstrated from several studies. The negative impact of PEM on brain growth could be reflected by the alterations of many anatomical and histological brain structures. Those alterations would be persistently ensued, since the impairment of cognitive and behavioral functions resided in those brain structures could be shown in the children’s later life.

Keywords: PEM, brain alterations, behavioral and cognitive functions

INTRODUCTION

Protein-energy malnutrition is one of many endangering disorders exhibited on children, particularly under five years old. The manifestation and incidence rate vary; 31 percent for underweight, 38 percent for stunted growth and 9 percent for wasting (Brabin and Coulter, cited in Muller and Krawinkel, 2005, p.3). Recently, worldwide estimation for that disorder is 852 million, nearly 96 percent occur in developing countries (FAO, cited in Muller and Krawinkel, 2005, p.2). As the increasing cases, the developing countries face the problem most. According to Indonesian Ministry of Health, during 2005 there were 3,553,024 children under five years suffered from undernutrition. The number is increasing by 42,766 new cases, with 43 mortality cases in 2006 (Depkes RI 2006).

World Health Organization (WHO) (1999) asserts that certain underlying diseases can be the cause, e.g. “unrecognized congenital abnormalities, inborn errors of metabolism, malignancies, immunological diseases and other diseases of the major organs”. In more fine points, WHO (1999) has made a classification for the disorder as shown in Table 1.

Table 1. Classification of malnutrition

<table>
<thead>
<tr>
<th>Classification</th>
<th>Moderate malnutrition</th>
<th>Severe malnutrition</th>
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<tbody>
<tr>
<td>Symmetrical oedema</td>
<td>No</td>
<td>Yes (oedematous malnutrition)</td>
</tr>
<tr>
<td>Weight-for-height</td>
<td>-3 ≤ SD-score &lt; -2</td>
<td>SD-score &lt;-3 (&lt;70%)</td>
</tr>
<tr>
<td>Weight-for-age</td>
<td>-3 ≤ SD-score &lt; -2</td>
<td>SD-score &lt;-3 (&lt;85%)</td>
</tr>
</tbody>
</table>

Source: (WHO, 1999)

In marasmus, lost of subcutaneous fat and muscles are mostly happened as the results of chronic deprivation of nearly entire carbohydrate and nutrients sources. A triangular face, primary or secondary amenorrhea, extended abdomen and anal or rectal prolapse would be noticed (Muller & Krawinkel 2005). The main problems are based on the degeneration of fatty acid metabolism which caused by carbohydrate impairment. Fatty degeneration would evident in many organs such as liver and heart. The latter would fail to function properly, hence myocardial insufficiency might occur. When oedema adjoins, the clinical condition would exacerbate into a cardiac failure (Muller & Krawinkel 2005).

The next imperiling conditions are hypoglycemia, dehydration and hypothermia due to the lost of body’s aptitude for temperature regulation and water storage. A failure on digestion ability could be exhibited also, since atrophic cells arise at the small bowel mucosa (Muller & Krawinkel 2005). In kwashiorkor, lack of protein
would cause the body fluid flows into the interstitial spaces, and lowering intravascular osmolar tension. Therefore, oedema and ascites would appear. Usually it could be pursued by the changes of hair and skin color, anemia, hepatomegaly, lethargy, severe immune deficiency and early death (Muller & Krawinkel 2005).

WHO (1999) stated that protein-energy malnutrition might amplify the propensity of the body to put up with many accompanying diseases and even death. Serious predispositions to get wasting, anorexia and infections also straightforwardly ensued. Hypoglycemia, hypothermia, dehydration, septic shock, skin infections, tuberculosis, helminthiasis, malaria, Human Immuno-deficiency Virus (HIV) infection and Acquired Immuno-deficiency Syndrome (AIDS) could be easily instigated (Muller & Krawinkel 2005).

DISCUSSION

Relating with the impact of protein-energy malnutrition to humans’ body, Maxwell (2005) avers that malnutrition has a significant impact on brain development. There is now evidence to show that poor nutrition affects cognitive development, psychomotor development, fine motor skills, skill acquisition, activity level, and social interaction. A contrast result about the correlation between birth weight and cognitive performance in later life are shown by two studies conducted by Martyn, Gale, Sayer and Fall (cited in Sorensen et al. 1997) and Sorensen et al (1997). The first group has reported a small correlation existed between low birth weight and poor cognitive results in later life, while Sorensen et al (1997) have provided sufficient evidence that the correlation is firmly parallel, based on the five times larger sample size data taken from about up to 4,300 Danish conscripts born between 1973-1975.

From the two studies above, the time span of protein-energy malnutrition impact on brain growth is still debatable. If the impact is persistently occurred, it should be shown as persistent anatomical and histological alterations of some cerebral cortices structures due to PEM. And for that reasons, the impairment of certain cognitive and behavioral functions resided in those cerebral cortices would be exhibited in later life. On the other hand, if the impairment is only temporarily happened as mended by nutritional rehabilitation, the physiological functions impairment mentioned would not be endured in adulthood.

Arguably, a study carried out by Calikoglu, Karayal and D’Ercole (2001) have reported that IGF-1 (Insulin-like Growth Factor-1) plays a considerable role in protecting brain growth from external endangering factors such as PEM. It was found that protein-energy malnutrition amended the m-RNA (messenger-ribonucleic acid) of IGF-1 located at the certain cerebral cortices. The production of IGF-1 in the brain was relatively different with those in liver under protein-energy malnutrition. IGF-1 would be aptly to augment in certain brain areas. Thus, this mechanism would shield the brain growth from frequently endangering circumstances including protein-energy malnutrition.

Whereas certain part of cerebral cortices could be degenerated by protein-energy malnutrition, many studies have revealed the subsistence of early particular period when brain development might be most susceptible to disturbing external factors including PEM (Gorman 1993). As Gorman reviewed from several studies, “the periods of gestation and the first two years of life continue to be important periods in the development of young children and have important implications for subsequent development”. She also implied that nutritional rehabilitation would achieve some beneficial results even though just been given outside these critical periods. However, many other researchers have asserted that despite nutritional rehabilitation given, neonatal malnutrition would remain decreasing cerebral cortices in volume (Bedi & Bhide 1988; Leuba & Rabinowicz, 1979a, 1979b; Morgane et al 1978; Thomas et al 1979; West & Kemper 1976 cited in Levitsky & Strupp 1993) and width (Cragg, 1972; Clark et al, 1973; Dobbing et al, 1971; Noback and Eisenman, 1981, Saisi and Saisi, 1973, West and Kemper, 1976 cited in Levitsky & Strupp 1993).

Since anatomical impairment alone would not be enough to proof the time span of PEM impact on brain growth, histological studies should be conducted. Though several studies alleged that some histological deteriorations in cerebral cortices might be recovered by nutritional rehabilitations, the recovery shown were only in the quantity of the cerebral cells and not the quality, (e.g., cortices cell packing (Bedi et al, 1980a; Leuba & Rabinowicz, 1979a; Saisi & Saisi, 1973; Thomas et al, 1979; Thomas et al, 1980; Warren & Bedi, 1988 cited in Levitsky & Strupp 1993), “cortical glial density” (Leuba & Rabinowicz, 1979a cited in Levitsky & Strupp 1993), and “cortical synapse:neuron ratio” (Diaz-Cintra et al. 1990 cited in Levitsky & Strupp 1993).

Since many anatomical and histological alterations of cerebral cortices could be occurred persistently after early PEM in spite of any nutritional rehabilitations administered, certain physiological functions resided in those lobes would be impaired as well in the later life. Bedi and Bhide (cited in Levitsky and Strupp 1993) reported that, the cognitive and intellectual function is primarily held in cerebral cortices (including hippocampus and parahippocampus in medial temporal lobes). Budson and Price (2005) stated that the main of “the episodic memory system” reside in the medial temporal lobes, including the hippocampus and parahippocampus, while semantic memory could be found in inferolateral temporal lobes, and “all working memory tasks” are located in prefrontal cortex. They also affirmed that many pathological processes, including malnutrition, could jeopardize memory function.

Additionally, revised study by Austin et al, and also by Jordan and Clark (cited in Levitsky & Strupp 1993) have found that impaired function of the hippocampus due to the previous malnourished condition on animal study could be identified as the inhibition of ‘long-term potentiation’ (LTP). The phenomenon was found as the result of the lack of adaptation on repetitive electrical stimulations to produce sub-seizure activities. It leads to equivalent associations between altered brain structures caused by malnutrition and the brain ability to response electrical stimulations, similar to what happened in active learning processes. Further observations done by Seimshaw and Gordon (cited in Levitsky and Strupp 1993). They found that children with early protein-energy malnutrition might tolerate some permanent low intellectual capacities, whilst Liu, et al (2004) have also asserted that early malnutrition especially lack of zinc, iron, and protein during pregnancy might cause altered brain development related with the rising of antisocial and aggressive behaviors in the children’s later life.

CONCLUSION

Protein-energy malnutrition would degenerate the brain growth mostly during a certain period of children’s life. Although the cells quantity of cerebral cortices might be mended by nutritional rehabilitations, the quality of the cells in certain brain areas might barely be, including the cells of hippocampus and parahippocampus in medial temporal lobes, inferolateral temporal lobes, and prefrontal cortex. Many persistent anatomical and histological alterations could be evidently exhibited; hence the impairment of some physiological functions resided in those areas (e.g. cognitive and behavioral functions) would be emerged in the children’s later life.

REFERENCES

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