Incidence of clinical features of micronutrients deficiencies and their immediate outcomes in children with severe acute malnutrition at NRC in Amravati region of central India

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***Abstract*—Micronutrients are vitamins and minerals fed in small quantities, but are essential for body biochemical processes. Severe acute malnutrition, among children below five years of age is global health problem contributing to childhood morbidity, mortality. Objective:This study aim was to accesses incidence of clinical features of micronutrients deficiencies and their immediate outcomes in children with severe acute malnutrition (SAM)on day 1 and after 15-day treatments with F-75/F-100plus vitamins mix.Methodology:The study was prospective observational conducted in the nutritional rehabilitation center (NRC) at district general hospital, Amravati for 6 months.The study was conducted on children aged between upto 60 months fulfilling the inclusion and exclusion criteria. Anthropometric measurements were taken to determine their nutritional status. The relevant information of individual childrenwas collected by using prevalidated case record collection form.Results: 100 patients of NRCwere enrolled in the study.Sixty nine percent (69) patients had weight/height Z score<−3 standard deviation, 16 % with Z score<−2 and 15% of Z score<−4 malnutrition.Mean age and median of population was 27.13±9.3 and 17.5 respectively. Vitamin B_{12}, iodine and vitamin E was found more than 50% population during study. After proper treatment of nutrition and maintain diet audit with some specific treatment of antibiotics all the findings were covered up during discharge. Micronutrient deficiencies were highly prevalent with vitamins and recovered on application of WHO protocols during hospitalization induced satisfactory recovery significant (p<0.05).**

***Index Terms*: Severe acute malnutrition (SAM), Nutritional rehabilitation center (NRC),Z score, Micronutrient**

1. INTRODUCTION

Inadequate dietary intake of nutritious food and infections including diarrheal diseases are major causes of growth faltering among infants [1]-[2]. Under nutrition may start as early as during foetal life as a consequence of inadequate food intake of the mother as well as strenuous work during pregnancy [3]-[4]. This causes growth faltering among the infants, which is often accelerated when complementary feeding starts and low-nutrient-density foods are used to replace breast milk [5]. Inadequate food intake also results from low meal frequency.Stunting in early life (0-5 years) has been linked to impaired cognitive, language, andmotor development [6]. However, improved nutrition and catch-up growth have been shown to improve or normalize development after stunting [7]. Significant growth and development of the brain occur in the last trimester of pregnancy until two years of age [8]. Micronutrients are vitamins and minerals fed in small quantities, but are essential for body biochemical processes. They are essential in producing enzymes, hormones and metabolites which are vital role for growth and development. Conditions of micronutrient deficiency are prevalent among two billion people in both developing and developed countries. There are silent epidemics of vitamin and mineral deficiencies which affect people of all ages and genders, as well as certain risk groups. Deficiencies in certain groups of people at specific risk need addition, but the maximum successful way to safely meet community health needs is through population-based interventions relating food fortification[9].Adequate macro- and micronutrient supply is essential for the growth and maintenance of brain tissue to support cognitive and social development [10]. Thus, nutrition indirectly affects children's behavior and experiences. Impaired cognitive function consequently affects the individual's ability to live a productive life and educational attainment[11].The role of micronutrients (essential trace elements and vitamins) in optimizing health and in preventing or treating disease has now become increasingly relevant. It stems in part from the enhanced knowledge and appreciation of such nutrients 'biochemical functions, but also from the extensive but less well-founded commercial claims for these substances. It is critical that doctors and other health professionals are aware of the evidence

for these substances 'nutritional essentiality and for circumstances where increased consumption can contribute to clinical benefit [12]-[13].In this study, two questions were thus addressed: what factors are associated with nutritional status among children in Amravati; and what is the relation between their nutritional status, diseases like Anemia, various eye and limb defects and overall development? This study focused on below 5 year old children because complementary feeding is recommended to start at 6 months [10], a critical time period when adequate nutrition is key in supporting social development. The aim of research paperis to study incidence of clinical features of micronutrients deficiencies and their immediate outcomes in children with severe acute malnutrition (SAM) at NRC in Amravati region of central India. This study could reveal the importance of micronutrients like vitamins, minerals and trace element needed for development of human body.From this study burden of diseases like Anemia, various eye and limb defects could estimate including other various effects on body.

2. MATERIALS AND METHODS

2.1 Study area

The prospective observational study was conducted in nutritional rehabilitation centre, district hospital, Amravati of vidarbha region in the state of Maharashtra among population for the period of six month. The institutional review board approved the present study.

2.2 Study design and participants

Patient was informed about the purpose of the study and written consent was taken prior to their participation in the study. An informed consent to participate in research of samples, ensure the confidentiality of the information received and used only for research purposes were fully met.All children between the age group of upto 60 months reporting consecutively in the department of Pediatrics and fulfilling any one of the following criteria as per WHO guidelines to define severe acute malnutrition with regard to growth parameters were included in study.A total of 100 children of age between 1 month to 6 months whose weight for height infants >45cm length, Z score <-3SD with or without bilateral pitting edema, for infants <45cm length, visible severe wasting with presence of bilateral pitting edema on both feet (excluding other causes of edema) and in infant more than 6 months of age (6 months to 5 years) mid upper arm circumference (MUAC) < 11.5 cm (115mm), bilateral pitting edema and glossy visible severe wasting were included in the study. Sample size calculations were based on a prevalence of 35% for stunting among 6 to 60 month old childrens of either sex of inpatient of NRC, district hospital, Amravati, profound diagnosis given by physician were included for this study [14].Those patient's caretaker not willing to sign consent, early discharged and children diagnosed with hemolytic anemia, congenital mental disorder (CMD), chronic kidney disease (CKD), congenital heart disease (CHD), and cerebral palsy were exclude.

2.3 Subjects, data collection, analysis and statistical methods

Sample size was 100 populations of nutritional rehabilitation centre, district hospital, Amravati over a period of six months from September 2019 to February 2020.Patient data relevant to the study has been collected from treatment charts/case sheets, laboratory reports and patient or patient's care giver's interview by using prevalidated case record patient data collection form. The data was categorized into socio demographic details of child and anthropometry measures, general findings, micronutrient deficiencies, lab investigations, daily diet plan, feeding questionnaire, routine treatment, immunization, discharge with overall outcomes and other relevant information.Nutritional status was evaluated using weight, length, head circumference (HC), and mid-upper arm circumference (MUAC), which were measured using standard procedures and calibrations recommended by WHO [15]. The anthropometric data including age in months were calculated and converted to z-scores (LAZ, weight-for-age z-scores (WAZ), weight-for-length z-scores (WLZ), midupper arm circumference z-scores (MUACZ), and head circumference z-scores (HCZ), and a nutritional assessment tool using the WHO standards [15]. Quantitative variables were analysed by measures of central tendency (mean and median) and dispersion (standard deviation). Student t-tests were used to compare the prevalence of deficiencies and their differences between groupsat a significance level with probability (p) of 0.05 [14].

3. RESULTS AND DISCUSSION

In our study, among children under five years of age, 5% was underweight, 15% were both underweight and stunting, and 29% were from all three underweight, stunting and wasting, 16% were stunting and wasting and 35% had wasting and underweight due to lack of food and the presence of disease. This conclude that more number of children were suffering from underweight due to insufficiency of food material, lack of knowledge about diet and health, hygiene and the presence of disease. Food intake is not proper as a result weight loss and the body burns down fats resulting into wasting. These factors are adversely impact on height into stunting.

3.1 Age group distribution and Z score of malnutritional children

Amongst the study, 46 were male and 54 were female. It was observed that more than half of children with SAM were female. Malnutrition is a serious global issue. As those children comes under <-3 SD criteria of Z score, or MUAC ≤11.5 cm or bilateral pitting edema are termed to be severe acute malnourished (SAM) children. Anthropometry is the simplest way for diagnosis of malnutrition and consists of height, weight, MUAC, presence of edema or not. According to WHO guidelines, Z score was determined by weight and height. Out of 100 childrens, 69, 16 and remaining 15 children were <-3 SD, <-2 SD and <-4 SD respectively. This results is indicated that malnutrition has become a serious issue in health system as children were deficient found with <-4 SD Z score which is an alarming sign. The cohort of children in age group is shown in Fig.1. The mean age of population was 27.13±9.3 (Mean±SD) and the range of ages was between <6-60 months. Median of different age grouped was 71.5 and frequency of childrens with age groups were not correlated based on result correlation coefficient (r^2=0.57). There were higher prevalence of severe acute malnutrition and micronutrient deficiency in children in age group 13-18 (25%).

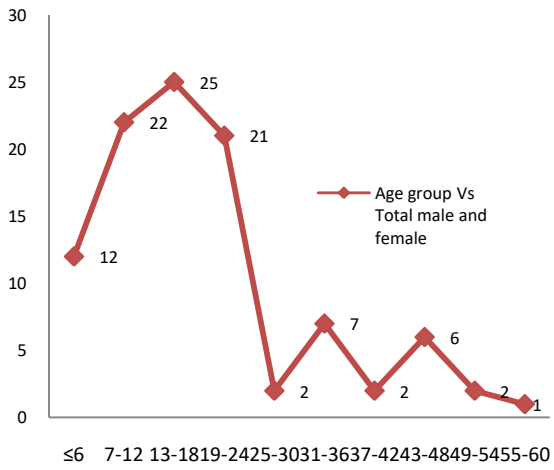

Figure 1: Age wise distribution of SAM children

The signs and symptoms of individual deficiencies that were observed in children were having that particular micronutrient deficiency. Through this it was possible to see that according to prevalence of each deficiency which signs are observed maximum in that particular deficiency. In the present study on observation of water soluble vitamin deficiencies in SAM patients, the vitamin B complex containing 100% children had deficiency of vitamin B6 (pyridoxine) at peak point in all of children population, 92% of vitamin B9 (folic acid), 90% of vitamin B_2 (riboflavin) and 59% of vitamin B_{12}while vitamin C was found in 99% of subjects [14]. Out of 100 children, 47% children were males and 53% children were females, with mean age and median of population were 27.13±9.3 and 17.5 respectively. Vitamin E deficiencies (53%) were highly prevalent in hospitalized SAM groups, followed by 28% vitamin D and 16% were vitamin A deficient [14].Each child was found to have more than 2 micronutrient deficiencies at a same time so it's very serious issue. So, education related to micronutrients is must in society so that all can stand for it and minimize the future generations from harmful effects.Table 1 is represents prevalence of individual micronutrient deficiency in children's. Nutrient prevalence is estimated from same group of population. It was found that highest prevalence of micronutrient deficiency was of iron and vitamin B_6. Zinc and vitamin C proved to be in high population (n=99). Folic acid (n=92) and vitamin B_2 (n=90) deficiency proved to be alarming. Least deficiency was found calcium. Similar study was carried out by Ahmed F. et.al prevalence in preschool children such Iron (10.7%), Zinc (44.5%), Vitamin A (20.5%), Vitamin B_{12} (31%), and Vitamin D (39.6%). One third of population was suffering from anemia [16], while in our study Anemia was found to be 100%.

Table 1: Prevalence of micronutrient deficiency

Sr. No	Micronutrient deficiency	Percentage of children (%)
1	Iron	100% (n=100)
2	Iodine	69% (n=69)
3	Zinc	99% (n=99)
4	Calcium	11% (n=11)

3.2 Incidences of vitamins, mineral and trace elements deficiencies with SAM

All necessary results of lab tests were recorded for the organ functioning of child as well as defects inside the body. These tests includes CBC, chest-X ray, kidney function test (KFT), liver function test (LFT), USG-abdomen were performed as per need.In total, 4 (22.22%)had each conjunctival xerosis and bitot's spot while 2 (11.11%) children of each had red and sticky eyes and xerophthalmia with bitot's spot. These four features were significantly associated with vitamin A deficiency. The ultimate solution for the prevention of this deficiency lies in educating people to eat food rich in vitamin A. Breastfeeding can protect children during first 6 months. From age of 6 months it is crucial to start semisolid food contains vitamin A. During the study, it was observed that each child was suffering from more than two micronutrient deficiencies. The maximum children were 16 of 54 (29.62%) vitamin E with other micronutrients deficient, followed by 6 of 28 (21.42%) vitamin D and 3 of 18 (16.66%) vitamin A with associated micronutrients deficient. The highest combined micronutrient deficiencies within enrolled subjects were observed significantly of vitamin E ($p<0.05$).

3.3 Iron deficiency associated with SAM

Children's having iron deficiency consist of signs as mentioned in table 2including pallor, glossitis, Irritability, loss of appetite, brittle nails, koilonychias, impaired mental and physical activity, fast heartbeat, breathlessness, and sore tongue.

Table 2: Signs of iron deficient children with SAM

Signs of iron deficiency	Number of child	Number of child (%)
Pallor	1	1
Irritability	2	2
Loss of appetite	3	3
Impaired mental and Physical activity	4	4
Brittle nails, Koilonychia	5	5
Sore tongue	6	6
Fast heartbeat, breathlessness	7	7
Stomatitis and glossitis	8	8
Pica	9	9

3.4 Iodine deficiency associated with SAM

The respective signs of iodine deficiency as shown in table 3. Children's having iodine deficiency consist of signs as swelling in neck, weakness, hair loss, dry flaky skin, changes in heart rate, both swelling in neck and weakness, trouble in learning. No single subject suffering from goiter and feeling colder than usual was found during the study.

Table 3: Signs of iodine deficient children with SAM

Signs of iodine deficiency	Number of child	Number of child (%)
Swelling in Neck	1	1
Weakness	2	2
Hair loss	3	3
Feeling colder than usual	4	4
Dry, flaky skin	5	5
Trouble in learning	6	6
Changes in heart rate	7	7
Goiter	8	8

3.5 Zinc deficiency associated with SAM

AcrodermatitisEnteropathica is a rare genetic autosomal recessive disorder, characterized by periorificial dermatitis, alopecia and diarrhea. It is caused by mutations in the gene that encodes a membrane protein that binds zinc. It occurs when body has very low count of zinc. This was one of the babies which was admitted in NRC due to this condition and was having severe zinc deficiency (Fig.2). It was also simultaneously suffering from other nutrient deficiencies. Children's having zinc deficiency consists of signs as anemia;skeletal abnormalities nail changes, growth retardation, skin lesions, and diarrhea.

Table 4: Signs of zinc deficient children with SAM

Signs of zinc deficiency	Number of child	Number of child (%)
Skeletal Abnormalities	1	1
Anemia	2	2
Diarrhea	3	3
Stomatitis	4	4
AcrodermatitisEnteropathica	5	5
Poor wound healing	6	6
Nail changes (color, infection)	7	7
Growth Retardation	8	8
Eye and Skin Lesions	9	9

3.6 Multiple micronutrient deficiencies in children

During the study, it was observed that each child was suffering from more than two micronutrient deficiencies. The percent wise distribution of multinutrient deficiency is shown in table 3. The maximum children were16 of 54 (29.62%) vitamin E with other micronutrients deficient, followed by 6 of 28 (21.42%) vitamin D and 3 of 18 (16.66%) vitamin A with associated micronutrients deficient. The highest combined micronutrient deficiencies within enrolled subjects were observed significantly of vitamin E ($p<0.05$).

3.7 Immediate outcomes of SAM patients at nutritional rehabilitation centre

There were 100 subjects in the study who were in the category so called Severe Acute Malnutrition, on examination physically and clinically it was observed that they were suffering from more than one micronutrient deficiencies and signs were severe and alarming as described above. Anemia was 100% found in all subjects. The child was started with supplementation. All micronutrients were administered from day 1 to 15 until discharge. Vitamin A was administered on day 1 only as per the guidelines given by WHO.

Table 3: Percent wise distribution of multinutrient deficiency with SAM

Sr. No.	Multiple deficiencies of micronutrients	Percentage of Children's (%)
1	A, D, E, B_{12}, Folic acid, B_6, B_2, C, Iron, Iodine, Zinc.	2
2	A, D, E, B_{12}, Folic acid, B_6, B_2, C, Iron, Iodine, Zinc, Calcium	2
3	A, D, E, Folic acid, B_6, B_2, C, Iron, Iodine, Zinc.	1
4	A, D, Folic acid, B_6, B_2, C, Iron, Zinc.	1
5	A, E, B_{12}, Folic acid, B_6, B_2, C, Iron, Iodine, Zinc.	1
6	A, E, Folic acid, B_6, B_2, C, Iron, Iodine, Zinc.	2
7	A, E, Folic acid, B_6, B_2, Iron, Zinc.	1
8	A, B12, Folic acid, B_6, B_2, C, Iron, Iodine, Zinc.	2
9	A, Folic acid, B_6, B_2, C, Iron, Iodine, Zinc.	2
10	A, Folic acid, B_6, B_2, C, Iron, Zinc.	1
11	A, B_6, B_2, C, Iron, Zinc.	1
12	D, E, B_{12}, Folic acid, B_6, B_2, C, Iron, Iodine, Zinc.	6
13	D, E, B_{12}, Folic acid, B_6, B_2, C, Iron, Iodine, Zinc, Calcium	3
14	D, E, B_{12}, Folic acid, B_6, B_2, C, Iron, Zinc.	1
15	D, E, Folic acid, B_6, B_2, C, Iron, Iodine, Zinc.	1
16	D, E, Folic acid, B_6, B_2, C, Iron, Iodine, Zinc, Calcium.	3
17	D, B_{12}, Folic acid, B_6, B_2, C, Iron, Iodine, Zinc.	2
18	D, B_{12}, Folic acid, B_6, B_2, C, Iron, Iodine, Zinc, Calcium.	1
19	D, B_{12}, Folic acid, B_6, B_2, C, Iron, Zinc.	1
20	D, B_{12}, Folic acid, B_6, C, Iron, Iodine, Zinc, Calcium.	1
21	D, Folic acid, B_6, B_2, Iron.	1
22	D, B_6, B_2, C, Iron, Iodine, Zinc, Calcium.	1
23	D, B_6, C, Iron, Zinc.	1
24	E, B_{12}, Folic acid, B_6, B_2, C, Iron, Iodine, Zinc.	14
25	E, B_{12}, Folic acid, B_6, B_2, C, Iron, Zinc.	5
26	E, B_{12}, Folic acid, B_6, C, Iron, Iodine, Zinc.	1
27	E, Folic acid, B_6, B_2, C, Iron, Iodine, Zinc.	5
28	E, Folic acid, B_6, B_2, C, Iron, Zinc.	3
29	E, B_6, B_2, C, Iron, Iodine, Zinc.	1
30	E, B_6, C, Iron, Iodine, Zinc.	1
31	B_{12}, Folic acid, B_6, B_2, C, Iron, Iodine, Zinc.	10
32	B_{12}, Folic acid, B_6, B_2, C, Iron, Zinc.	3
33	B_{12}, Folic acid, B6, C, Iron, Zinc.	2
34	B_{12}, B_6, C, Iron, Iodine, Zinc.	1
35	B_{12}, B_6, C, Iron, Zinc.	1
36	Folic acid, B_6, B_2, C, Iron, Iodine, Zinc.	6
37	Folic acid, B_6, B_2, C, Iron, Zinc.	7
38	Folic acid, B_6, C, Iron, Zinc.	1
39	B_6, C, Iron, Zinc.	1

Other like folic acid, calcium, iron, zinc, potklor, magnesium sulphate, MVBC doses were calculated as per weight of child. Depending on appetite test result feed formula was started to each child (F-75/F-100). The quantity administered per day was calculated as per their weight and requirements. Special feed comprising of roasted groundnuts, milk powder, coconut oil and sugar mixture was also provided(33 gm./25 gm.) in NRC with other complementary feed like rice, dal, paratha, soups etc. So, definite amount of calories was taken by child daily. Day by day it was observed that the subjects are responding positively as the food and doses of micronutrients continued. Also breastfeeding counseling was done to all mothers and breastfeeding was also with all this therapy. Slowly child became playful and all the above discussed signs of micronutrient deficiencies were nil at the time of discharge and child was with 15% weight gain.

On physical examination we diagnosed many serious signs which represent particular deficiency of vitamins, minerals, and trace elements. Anemia was found in all 100% population by observation

and also through laboratory investigations reports (CBC). Based on Signs and symptoms as discussed in results and Clinical reports it was found that Vitamin B_6 and Iron deficiencies were found at peak point in 100% subjects while vitamin C and Zinc was found in 99% subjects. Folic acid deficiency was also present in large population while others also prove to be alarming signs to the society about health care in Children's. Vitamin B12, Iodine and Vitamin E was also found to be in more than half i.e. 50% population during study. Each child was found to have more than 2 micronutrient deficiencies at a same time so it's very serious issue. So, education related to micronutrients is must in society so that all can stand for it and minimize the future generations from harmful effects. So treatment was started from the day of admission. Proper diet audit was created as per need of child, zinc supplements and all other care was given to child for entire 15 days duration. Day by day intake was increasing and all the symptoms were recovered till day of discharge (Fig.2).

Figure 2: Comparison of AcrodermatitisEnteropathica on admission and discharge

3.8 Immediate outcomes of SAM patients at nutritional rehabilitation centre

On Admission, 16 subjects were having Z score below -2 SD but as these children's follows other criteria of SAM i.e. their MUAC was less than 11.5 cm (115 mm), some of them had bilateral pitting oedema, All 16 were having poor appetite and was present with clinical signs hence they are diagnosed to be SAM. Other samples were (69) Z score below –3 SD and (15) below -4 SD (Below -3 SD). On day of discharge, out of 100 subjects, 91 subjects gained 15% weight and all were above -3 SD regarding Z score as shown in Fig. 4. Those who had bilateral pitting oedema were been cured. MUAC was also found to be increased in some children's and most important all were having good appetite and were free from all clinical signs of SAM and micronutrient deficiencies. Regarding other 9 subjects, they were below -3 SD regarding Z score. 5 were discharge on request and 4 were medically transferred to other hospital due to emergency of their co-morbidities but their general findings were normal on the day of discharge. After proper planned diet (F-75/F-100, special feed, complementary feed) along with breastfeeding and treatment of micronutrients, out of 100 population, 91%, 5% and 4% were completely cured, discharge on request and medically transferred due to other co-morbidities as shown in Fig. 3.

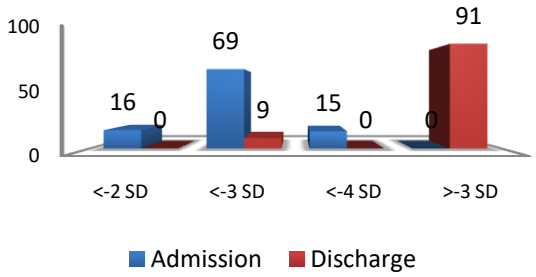

Figure3: NRC performance for SAM patients by Z score outcome

At the time of admission, 89 did not have pitting oedema, but 11 were found present. After complete treatment it was found that during discharge day all 100 were free from bilateral pitting oedema. This suggest that due to proper diet intake proteins level is stable in child and due to this no more fluid gets leaked out of blood vessels. General findings were observed stools, vomiting, dehydration, cough, fever and pale conjunctiva (Fig. 4).

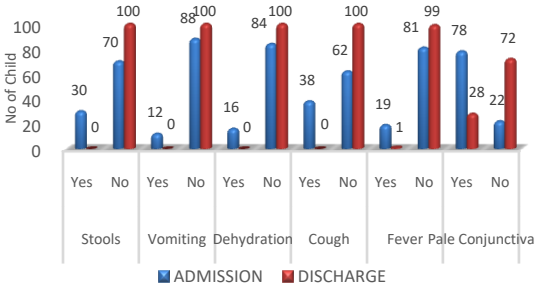

Figure 4: General findings outcomes

During Admission, the complications in subjects were stools (30%), vomiting (12%), dehydration (16%), cough (38%), fever (19%), and pale conjunctiva (78%). After proper treatment of nutrition and maintain diet audit with some specific treatment of antibiotics all the findings were almost covered up. Only one child was having mild fever and 28% had very mild pale conjunctiva during discharge. The death, defaulter, non-responder, unknown cause was not observed during entire conduction of study in nutritional rehabilitation centre (NRC).Recovery rate of fat soluble vitamins on admission and discharge (before and after hospitalization) was taken into consideration for comparison of performance of NRC and it was statistically significant (p= 0.016). Hence use of micronutrients during hospitalization was significant on cured of child ($p<0.05$). Weaning is a crucial transition in childhood nutrition. The transition from breast feeds to introduction of complementary food at this point should be

appropriate and optimum to meet the protein, energy and micronutrient needs of the child.

4. CONCLUSION

Prevalence of micronutrient was more in age group of 13-18 months. On physical examination and diagnosed report many childrens were found more than two micronutrient deficiencies particular deficiency of vitamins, minerals, and trace elements at a same time.Protocol use of feeding and appropriate therapeutic supplementation during hospitalization was significant on (91%) cured of child ($p<0.05$)..

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