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Stoy N, Mackay GM, Forrest CM, Christofides J, Egerton M, Stone TW, Darlington LG (2005). Tryptophan metabolism and oxidative stress in patients with Huntington's disease. *N. J. Neurochem.* 93: 611-623.

Mussel RL, De Sa Silva E, Costa AM, Mandarim-De-Lacerda CA (2003). Mast cells in tissue response to dentistry materials: an adhesive resin, a calcium hydroxide and a glass ionomer cement. *J. Cell. Mol. Med.* 7:171-178.

Booth M, Bundy DA, Albonico P, Chwaya M, Alawi K (1998). Associations among multiple geohelminth infections in school children from Pemba Island. *Parasitol.* 116: 85-93.0.

Fransiscus RG, Long JC (1991). Variation in human nasal height and breath, *Am. J. Phys. Anthropol.* 85(4):419-427.

Stanislawski L, Lefeuvre M, Bourd K, Soheili-Majd E, Goldberg M, Perianin A (2003). TEGDMA-induced toxicity in human fibroblasts is associated with early and drastic glutathione depletion with subsequent production of oxygen reactive species. *J. Biomed. Res.* 66:476-82.

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*Full Length Research Paper*

# Seroprevalence of syphilis among male blood donors by enzyme linked immunosorbent assay in Thi-Qar province, Iraq during 2007 to 2011

Saad S. Hamim

Department of Pathological Analysis, College of Science, Thi-Qar University, Iraq.

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The prevalence of infectious diseases is increasing in developing countries, and this may threaten the biological safety of donated blood. The present study aimed to investigate the seroprevalence of syphilis among male blood donors in Thi-qar province, Iraq during the period of 2007 to 2011. The study was carried out at the central blood bank of Al-Nasiriyah city, Iraq for a period of five years and screened all male blood donors for syphilis using enzyme-linked immunosorbent assay (ELISA) technique. Results were confirmed by using alternative commercial kits in the Central Health Laboratory in Baghdad. Chi-square ( $\chi^2$ ) test was used to evaluate the study result. From 2007 to 2011, a total of 52,723 male blood samples were analyzed. The overall prevalence rate of syphilis infection was (0.36%) with 192 donors showed positive sera for the five years study period with a high number of infections in 2011 year with 111 donor (57.81%). The age of donors ranged between 18 and 71 years old. The age group of 50 to 59 years showed the highest number of infections with 110 donors (57.29%), while the lowest numbers of infections were recorded in 18 to 28 age group with 9 donors (4.69%). Labourers were the most group infected with syphilis with 131 donors (68.22%), followed by policemen and civil servants with 38 (19.80%) and 23 (11.98%), respectively. According to health sections, Nasiriyah section recorded the highest infections with 146 donor (76.04%), followed by Al-Shatra, Suk-Alshuuk and Al-Refaae health sections with 24 (12.50%), 14 (7.30%) and 8 (4.16%), respectively. The present study finding may suggest that syphilis infections continue to be low in Iraq, but need more follow up programs to improve safety of blood transfusion process.

**Key words:** Blood donors, enzyme linked immunosorbent assay, seroprevalence, syphilis, labourers.

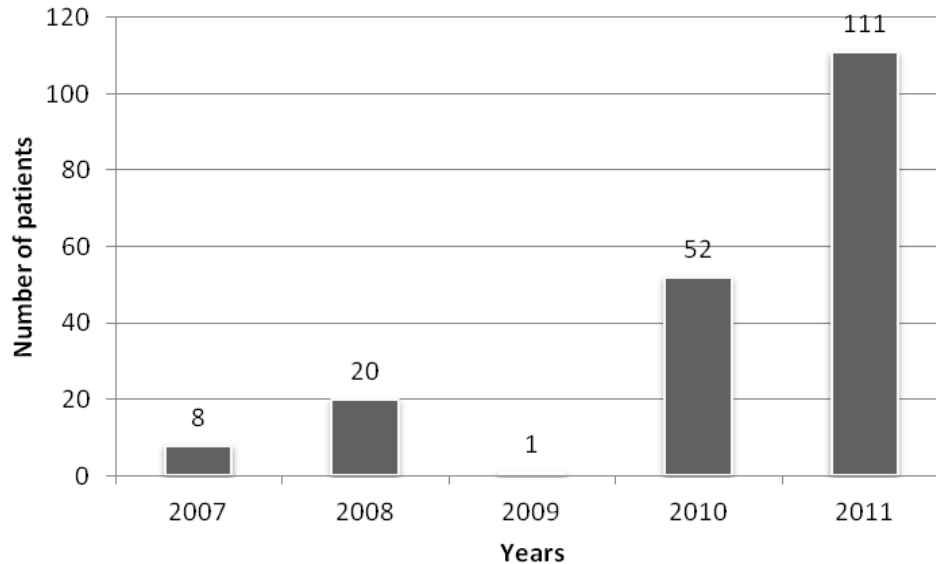
## INTRODUCTION

Transfusion-transmitted infections (TTIs) acquired through the therapeutic blood transfusion process is a major universal health problem in transfusion medicine that should be addressed. Therefore, minimizing this

complication should be encouraged (Salawu et al., 2010). Hepatitis B virus (HBV), hepatitis C (HCV), human immunodeficiency virus (HIV) and syphilis infections are public health problems that share similar routes of

E-mail: [saad@sci.thiqaruni.org](mailto:saad@sci.thiqaruni.org). Tel: 009647801016056.

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**Figure 1.** Distribution of syphilis patients according to the study years.

transmission such as sexual contact, exposure to contaminated blood or blood products, the dangerous tradition of sharing needles, intravenous drug use and transfer from mother to child (Mast et al., 2005; Alter, 2006).

Syphilis is classified as a sexually transmitted infection (STI) caused by the *Treponema pallidum* spirochete; if not treated, syphilis can cause serious effects such as damage to aorta, brain, eyes and bones. In some cases, these effects may be fatal (Olokoba et al., 2008). This study aimed to investigate the prevalence of syphilis among male blood donors in Nassyriah city, Iraq during the period of 2007 to 2011.

#### MATERIALS AND METHODS

The present study was carried out and supported by central blood bank in Thi-Qar province, Iraq over a period of five years (2007 to 2011). In this duration the blood was collected from apparently healthy 52723 donors. Name, age, sex, occupation and address were recorded from each donor. The sera obtained after blood centrifugation were screened immediately for the detection of syphilis by using enzyme linked immunosorbent assay (ELISA) technique for the qualitative determination of IgG/IgM type antibodies to *T. pallidum* and according to the instructions of manufacturer companies. The study was approved by science college ethics committee.

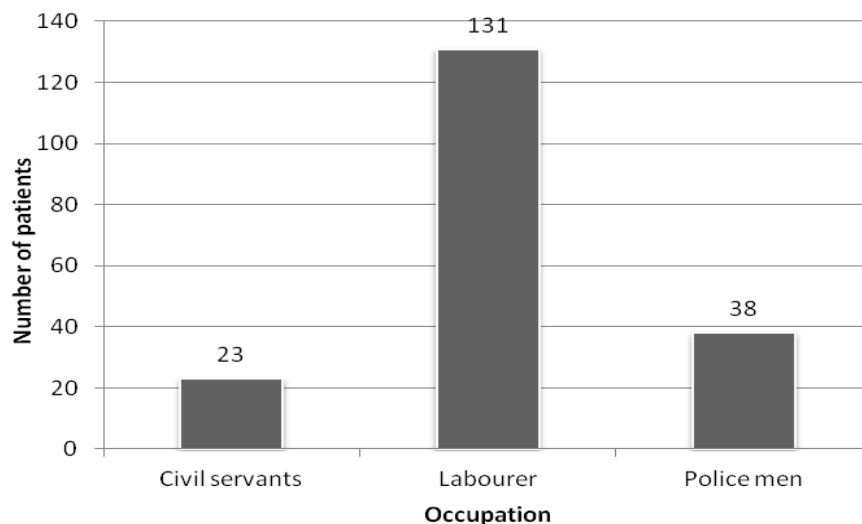
#### RESULTS AND DISCUSSION

A total of 52723 male blood donors were screened for over a period of five years. Of these donors, there were 192 seroactive cases with a percentage of (0.36%). As shown in Figure 1, there was a noticed increase in infected donors with syphilis, except in 2009 year which

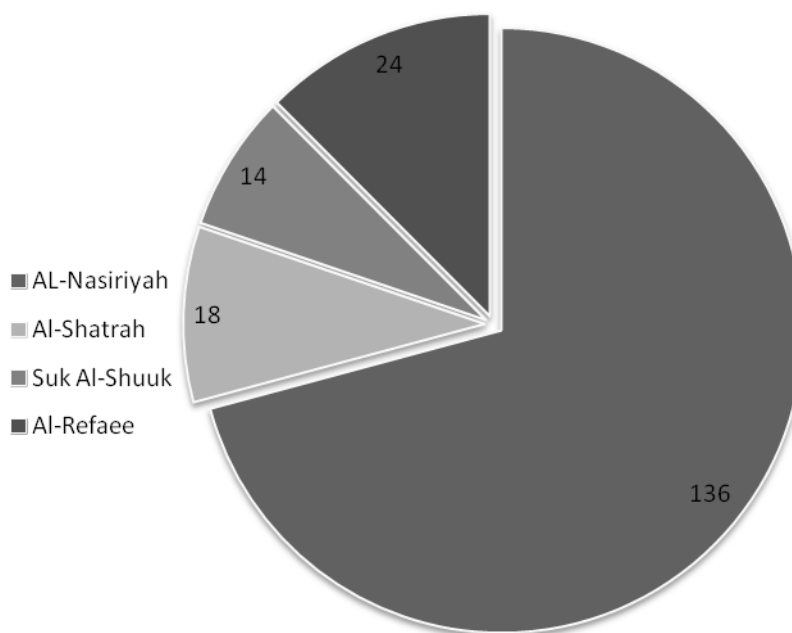
showed a low numbers of infected donors with 1 donor (0.52%). The highest number of infections was recorded in 2011 with 111 donors (57.81%) ( $p < 0.005$ ). Timely transfusion of blood saves millions, but unsafe transfusion practices put millions of people at risk of transfusion transmissible infections (Bihl et al., 2007). The increased number of infected donors in recent years was noticed in other similar survey studies (Kaur et al., 2010; Sinha et al., 2012). The age of donors ranged from 18 to 71 years. The age group of 50 to 59 years had the highest prevalence of syphilis positive cases with 110 donors (57.29%). While the lowest positive sera were recorded in 18 to 28 age group with 9 (4.69%) donors ( $p < 0.005$ ). These finding was at variance from other studies (Olokoba et al., 2009; Nwankwo et al., 2012). The differences in the syphilis infection rate among the different studies may be due to differences in geographical locations, age range of blood donors, sample size, the period of the time of the studies carried out and different socio-cultural practices such as sexual behavior and marriage practices (Olokoba et al., 2009).

According to occupation as shown in Figure 2, majority of syphilis infections were recorded in labourers with 131 donor (68.22%), followed by policemen and civil servants with 38 (19.80%) and 23 (11.98%) donors, respectively ( $p < 0.005$ ). The lower or may be the absence of the education levels in most of Iraqi labourers may reflex the high incidence of syphilis in this group. These results were similar to that of what Tessema et al. (2010) found in Ethiopia. In the other hand, Alkoba et al. (2009) found that civil servants donors were more effected with syphilis.

Al-Nasiryah health section recorded the highest syphilis infections with 146 donors (76.04%), followed by Al-Shatra, Suk-Alshuuk and Al-Refae health sections



**Figure 2.** Distribution of syphilis patients according to occupation.



**Figure 3.** Distribution of syphilis patients according to medical sectors.

with 24 (12.50%), 14 (7.30%) and 8 (4.16%) blood donors, respectively ( $p < 0.005$ ) (Figure 3). Majority of syphilis infections recorded in Al-Nasiriyah section may be explained by the crowded population, in which this city is the center of Thi-Qar province.

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*Full Length Research Paper*

## Interplay between nitric oxide (NO) and glucose 6-phosphate dehydrogenase (G6PD) activity in primary hypertension

Mwenya Kwangu<sup>1,2</sup>, Pierre Yassa<sup>3</sup>, Nason Lambwe<sup>3</sup>, Moses Mukosha<sup>1</sup> and Gibson Sijumbila<sup>1\*</sup>

<sup>1</sup>Department of Physiological Sciences, School of Medicine, University of Zambia, Zambia.

<sup>2</sup>School of Medicine, Copperbelt University, Ndola, Zambia.

<sup>3</sup>Department of Internal Medicine, University Teaching Hospital, Lusaka, Zambia.

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Essential hypertension is one of the most prevalent non-communicable diseases in sub-Saharan Africa and elsewhere in people of sub-Saharan origin. This study investigated the role of nitric oxide (NO) and glucose 6-phosphate dehydrogenase (G6PD) activity in aetiology of essential hypertension. An analytical cross-sectional design was applied to 89 essential hypertensive participants and 89 healthy normotensive participants, making a total of 178. Blood was collected for G6PD activity and serum levels of nitric oxide, glucose, creatinine, urea and electrolytes. Analysis of variance was employed to establish whether there was a difference in mean levels of NO between those that were G6PD deficient and those who were not. Lower NO levels were observed in those who were G6PD deficient though the difference was not statistically significant. A logistic regression was used to investigate the association of age, sex, NO levels, and G6PD deficiency with essential hypertension as the dependant variable. It was established that with an increase in NO levels there was less likelihood of developing hypertension (odd ratio (OR)=0.99), whereas individuals with impaired G6PD activity were 2.9 times more likely to develop hypertension than those with normal activity (OR=2.9). Our conclusion was that NO is important in prevention of hypertension through its vasodilator effect on arterioles.

**Key words:** Hypertension, nitric oxide (NO), glucose 6-phosphate dehydrogenase (G6PD), reactive oxygen species.

### INTRODUCTION

Hypertension by definition is an increase in blood pressure above normal. If this is caused by an identifiable underlying factor, it is known as secondary hypertension. If no cause can be found, then it is primary hypertension and most hypertensive individuals belong to this category. Though no identifiable cause can be found for primary hypertension, there are always risk factors that

contribute to its development (Wamala et al., 2009). Primary hypertension is a world-wide problem with variations in prevalence, with the lowest prevalence in rural India (3.4% in men and 6.8% in women) and the highest prevalence in Poland (68.9% in men and 72.5% in women) (Kearney et al., 2004). In fact hypertension is the most common cardiovascular disorder affecting

\*Corresponding author. E-mail: [gibson.sijumbila@unza.zm](mailto:gibson.sijumbila@unza.zm). Tel: +260979352149.

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approximately 1 billion people globally and accounts for approximately 7.1 million deaths annually (Brundtland, 2002). Primary hypertension is one of the most common non-communicable diseases in Zambia with high morbidity due to cardiovascular complications that result from untreated cases. Though no national surveys have been carried out, evidence coming from localized surveys and hospital statistics suggest that hypertension is a very prevalent medical condition. For instance a population based survey carried out in Lusaka Urban district of Zambia showed the prevalence of hypertension to be 34.8% (38.0% of males and 33.3% of females) (Goma et al., 2011). What is even more disturbing is the fact that many people with hypertension are not aware that they have the condition (France, 1999). Studies have shown that ethnicity, emotional stress, genetic factors, advancing age, obesity, alcohol consumption, level of education and inactivity are some of the risk factors leading to development of hypertension (Kulkarni et al., 1998; Anderson, 1999; Dominiczak et al., 2000; Vasan et al., 2002).

Untreated high blood pressure leads to serious complications like stroke, heart failure, myocardial infarction, renal insufficiency or failure, peripheral vascular disease, retinopathy, dementia, with high morbidity and mortality (Flack et al., 2003).

Among the many chemical messengers that seem to have a role in regulation of blood pressure is nitric oxide (NO) (Dominiczak and Bohr, 1995). NO is involved in a lot of physiological processes like immune responses, cell signalling, neurotransmission and many others (Rosselli et al., 1998). It is formed from L-arginine by endothelial NO synthase using reduced nicotinamide adenine dinucleotide phosphate (NADPH) as a cofactor (Mehta et al., 2003). The main source of this NADPH is the pentose phosphate pathway, whose rate limiting step is catalysed by glucose 6-phosphate dehydrogenase (G6PD); hence, changes in activity of this enzyme can affect production of NADPH accordingly. Apart from NADPH acting as a cofactor in the synthesis of NO, it also provides reducing power for destruction of hydroxyl radicals that inactivate NO. NO relaxes the smooth muscles in the walls of arterioles; at each systole, the complex endothelial cells that line the blood vessels, will release a puff of NO, which then diffuses in the underlying smooth muscle cells. This process causes these cells to relax, which permits a surge of blood to pass through easily (Ignarro, 1989). Therefore, we decided to investigate if there was an association between NO levels and essential hypertension in Zambian participants. This study also went on to determine if there was a significant difference in NO levels between G6PD deficient individuals and those with normal G6PD activity.

## MATERIALS AND METHODS

This study was conducted at the University Teaching Hospital (UTH), the largest national referral hospital in Zambia. It provides

treatment services and medical check-ups for most of the population in Lusaka. An analytical cross-sectional study design was used. The target population included all the hypertensive patients coming to filter clinic to be attended to, and controls were mainly participants who were coming to the hospital with minor ailments or for medical check-ups. All participants had to undergo a thorough medical examination to rule out any chronic diseases or secondary causes of hypertension. Any client who was between 35 and 65 years inclusive and willing to participate was recruited. Those who were pregnant, obese, chronically ill or with secondary causes of hypertension were excluded. The systematic random sampling method was employed, where every 3rd person was selected for the study after a thorough medical examination by the medical doctor on duty. About 4 ml of venous blood was collected from the antecubital vein for the purposes of determining G6PD activity, blood levels of nitric oxide, glucose, creatinine, urea and electrolytes. Based on an expected prevalence of essential hypertension of 50% in the general population and 6% G6PD deficiency in normotensives, 89 participants were enrolled, giving a total of 178 participants.

NO levels were determined as described elsewhere (Moshage et al., 1995). Briefly, this assay determines NO based on the enzymatic conversion of nitrate to nitrite by nitrate reductase. The reaction is followed by a colorimetric detection of nitrite as an azo dye product of the Griess reaction. G6PD activity was measured using the quantitative spectrophotometric method as outlined elsewhere (Lohr and Waller, 1958). In brief, the method relies on the fact that nicotinamide adenine dinucleotide phosphate (NADP<sup>+</sup>) is reduced to NADPH by G6PD in the presence of glucose 6-phosphate. The rate of formation of NADPH is proportional to the activity of G6PD and is measured spectrophotometrically as an increase in the absorbance at 340 nm.

## Statistics

Data was analysed using STATA® Version 12 (STATA Corporation, College Station, Texas). The first step in this section dealt with summary statistics for continuous variables for both groups (study and control groups). Means and standard deviations were used to come up with the descriptive statistics for continuous variables. The continuous and categorical variables were compared using the unpaired student t-test and chi-square, respectively. In order to determine whether the mean of NO levels differed between those who were G6PD deficient and those who were not, analysis of variance (ANOVA) was employed.

Other variables that are believed to influence essential hypertension such as gender and age were defined. Then the significance of these factors was first tested using a bivariate logistic regression to determine the effect of each independent variable on the dependant variable (essential hypertension), then a multivariate logistic regression was performed to rule out possible confounders. The odds ratios were used to establish the degree of association between NO and essential hypertension.

## RESULTS

The study group consisted of 89 hypertensive patients with a mean age of  $52.6 \pm 10.4$  which was greater than that in the control group ( $43.8 \pm 9.0$  years) and the difference was significant ( $P < 0.0000$ ). NO levels in essential hypertensives were significantly lower than in normotensives ( $p < 0.001$ ). Other variables whose means came out to be significant at 5% included serum glucose, creatinine and sodium levels all with p-values less than

**Table 1.** Descriptive statistics for essential hypertensive patients and control participants.

Parameter	Essential hypertensive patients (study group) ( n=89)		Normotensive (control group) (n=89)		P-values (cases vs. controls)
	Mean	SD	Mean	SD	
Age (Years)	52.1	10.4	43.8	9.0	<0.000
NO (µM)	70.0	39.9	96.5	48.6	<0.001
pH	6.6	0.3	6.6	0.3	0.25
Specific gravity	1.0	0.0	1.0	0.0	0.07
Glucose (Blood ) (mmol/L)	5.2	0.8	5.0	0.9	0.03
Urea (mmol/L)	3.8	1.1	3.6	0.9	0.08
Creatinine (mg/dl)	0.7	0.1	0.7	0.2	0.05
Sodium (mmol)	136.6	1.5	137.1	2.3	0.03
Potassium (mmols)	3.7	0.2	3.7	0.2	0.40
Chloride (mmols)	100.0	2.6	100.2	3.0	0.39
G6PD deficiency, n (%)	14 (15.7)	-	9 (10.11)	-	0.13

**Table 2.** NO levels by G6PD ANOVA results.

NO levels by G6PD	ANOVA				
	Sum of squares	df	Mean square	F	Sig.
Between groups	1682.899	1	1682.899	0.785	0.377
Within groups	377109.489	176	2142.668		
Total	378792.388	177	-	-	-

**Table 3.** NO levels mean comparisons between those with G6PD deficiency and those with normal G6PD activity.

NO levels by G6PD	Mean	N	Standard deviation
Less than 10.01 U/g hemoglobin	75.30	23	37.886
Greater than 10.01 U/g hemoglobin	84.47	155	47.368
Total	83.29	178	46.261

0.05 (Table 1).

In order to test whether the mean of NO levels differed between those who are G6PD deficient and those who are not, ANOVA was employed and the results of the analysis are presented as shown in Table 2.

The results of the analysis of variance show that the mean of the dependent variable (NO levels) does not differ significantly (P-value = 0.377) between those with G6PD deficiency and those with normal G6PD activity. This is despite the comparison of means (Table 3) showing that those with G6PD activity greater than 10.01 U/g hemoglobin (Hb) have a higher value of NO level (84.47 µM) compared to those with G6PD deficiency (NO level of 75.30 µM) (Table 3).

A bivariate logistic regression was performed to determine the effect of each independent variable on the dependent variable (essential hypertension), after which a multivariate logistic regression was done to control for potential confounders.

Table 4 presents the results for the unadjusted odds ratio for the bivariate logistic regression. The results indicate that only age and the levels of NO have a significant effect on hypertension at 5% significance level. The findings also indicated a significant association between NO levels and essential hypertension with the odds ratio showing a decreased risk for essential hypertension [OR] = 0.99, 95% [CI] = 0.48 - 1.58, p = 0.00.

Table 5 reveals that age, and G6PD deficiency all are positive and significantly associated with increased risk of hypertension, while NO is associated with reduced risk of essential hypertension. The results further indicate that participants with G6PD deficiency were 2.92 (95% CI: 1.07 - 7.95) times more likely to develop hypertension than those without the G6PD deficiency, while an increase in NO levels was more likely to lead to decreased risk of having essential hypertension (OR = 0.99, CI = 0.98 - 0.99).

**Table 4.** Bivariate logistic regression with essential hypertension as the dependent variable with unadjusted odds ratios (Number of cases = 89; Number of controls = 89).

Variable		P-value	Unadjusted OR (95% CI)
Age category(in years)	35-45		1.00
	46-55	0.05	2.21 (0.99-4.96)
	56-65		5.76 (2.72-12.21)
Gender	Female	0.65	1.00
	Male		0.87 (0.48-1.58)
NO levels (uM)	-	0.00	0.98 (0.98-0.99)

**Table 5.** Logistic regression for predictors of development of essential hypertension among 35-65 year olds screened at UTH.

Variable	Found with essential hypertension after screening		Unadjusted OR (95% CI)	Adjusted OR (95% CI)	
	Yes [n (%)]	No [n (%)]			
Age category(in years)	35-45	30 (33.7)	59 (66)	1.00	1.00
	46-55	18 (20.2)	16 (18)	2.21 (0.99-4.96)	2.41 (1.05-5.54)
	56-65	41 (46.1)	14 (15.7)	5.76(2.72-12.21)	7.31 (3.22-16.61)
Gender	Female	42 (47.2)	39 (43.8)	1.00	1.00
	Male	47 (52.8)	50 (56.2)	0.87 (0.48-1.58)	0.79 (0.39-1.60)
NO levels (uM)	-	-	-	0.98 (0.98-0.99)	0.98 (0.97-0.99)

OR: Odds ratio; NO: nitric oxide; CI: confidence interval; G6PD: glucose-6-phosphate dehydrogenase.

## DISCUSSION

Our findings in this study show that an increase in the NO is less likely to lead to development of essential hypertension based on the multivariate logistic regression where the odds ratio was established to be 0.99 (OR < 1). These findings corroborate what has been reported by others. NO levels were found to be significantly lower in women in prehypertensive phase of essential hypertension. In this case, lower NO correlated with increased systolic blood pressure (Gerasimovska-Kitanovska et al., 2005). In a case control study carried out in India, the findings suggested that the normal homeostasis of NO and adhesion molecules may play a significant role in the pathophysiology and hence, the risk of essential hypertension (Srivastava et al., 2006). In another study, it was found that dilator action of endothelium-derived NO contributed to the control of basal and stimulated regional blood flow in humans (Vallance et al., 1989). Impairment of production of NO might account for the abnormalities in vascular reactivity that characterise a wide variety of disease states. From this we concluded that NO is important in the maintenance of normal blood pressure and its increase may lead to less chances of developing hypertension. It can therefore be concluded from the

study that there is an association between NO levels and essential hypertension, where an increase in the NO levels leads to reduced risk of developing essential hypertension.

Even though our results showed that NO levels were significantly lower in hypertensives than normotensives, there was no significant difference in mean levels of NO between G6PD deficient individuals and those with normal G6PD activity irrespective of blood pressure status. The probable mechanism for the interplay between NO and G6PD activity in primary hypertension may be that reduced G6PD activity forms less NADPH which eventually leads to decreased rate of NO synthesis. Reduced NO synthesis in turn minimizes vasodilator action on smooth muscle in arterioles. In addition, NADPH provides reducing power for removal of hydroxyl radicals which inactivate NO. Therefore, when NADPH is reduced due to inactivity of G6PD, more NO is inactivated predisposing the individual to hypertension as the vasodilator effect will have been curtailed.

It was also found out as expected, age to have a positive association with essential hypertension. This is supported by a study conducted on the prevalence of hypertension and it correlates in Lusaka Urban district of Zambia, where it was found that age and sex were



associated with hypertension (Goma et al., 2011). In our study, however, it was found out that sex had no association with essential hypertension [OR] = 0.79, [CI] = 0.39 - 1.60 (P = 0.6). Systolic blood pressure and pulse pressure increase with age mainly because of reduced elasticity (increased stiffness) of the large conduit arteries. Arteriosclerosis in these arteries results from collagen deposition and smooth-muscle cell hypertrophy, as well as thinning, fragmenting, and fracture of elastin fibers in the media (Oparil et al., 2003). Endothelial dysfunction due to age may reduce synthesis of NO which in turn could reduce arterial compliance resulting in increased blood pressure (Safar, 1999).

It is worth noting that the liver is one of the organs where the pentose phosphate pathway, the main source of NADPH, is very active. In view of the fact that obesity, one of the risk factors for development of essential hypertension, is associated with non-alcoholic fatty liver disease patients should have been screened by ultrasound for the presence of hepatic steatosis (Tarantino et al., 2012), but this could not be done due to limited facilities. This is important because steatosis is associated with a high risk of developing type 2 diabetes mellitus, dyslipidemia (high plasma TG and/or low plasma HDL-cholesterol concentrations), and hypertension (Adams et al., 2005). In addition, levels of serum alanine amino transferase and  $\gamma$ -glutamyltransferase should have been determined as it has been shown that high levels  $\gamma$ -glutamyltransferase is associated with hypertension (Tarantino et al., 2012). Steatosis may predispose to hypertension probably because the pathological change associated with the condition impairs the pentose phosphate pathway leading to reduction in NADPH formation.

Our conclusion was that NO is important in prevention of hypertension through its vasodilator effect on arterioles. It remains to be elucidated whether essential hypertension is caused by a defect in endothelial NO synthesis or by an impaired vascular response to nitric oxide. If indeed a defect in synthesis of NO was the cause of essential hypertension, perhaps clinical trials could be recommended where administration of supplements, which upon metabolism release NO would be given in essential hypertension. Additional studies will be required to determine the NO levels in hypertensives with normal and low G6PD activity; and in normotensives with normal and low G6PD activity.

### Conflict of Interests

The author(s) have not declared any conflict of interests

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Full Length Research Paper

# Severely inflamed Meckel's diverticulum in infancy mimicking acute appendicitis: A diagnostic conundrum

Uledi Sefu Juma<sup>1\*</sup> and Masumai Fauzia Ayubu<sup>2</sup>

<sup>1</sup>Surgery Department, Mzuzu Central Hospital, Mzuzu, Malawi.

<sup>2</sup>Department of Obstetrics and Gynaecology, Mzuzu Central Hospital, Mzuzu, Malawi.

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Meckel's diverticulum occurs around the fifth to seventh week of the embryological development. It originates when the vitelline or omphalomesenteric duct which normally connects the primitive gut to the yolk sac fails to obliterate. Meckel's diverticulum may be symptomatic or remain silent throughout life time and incidentally discovered at autopsy. Symptoms primarily emanates from an array of complications which may include diverticulitis, haemorrhage, obstruction and intussusceptions. Diverticulitis predominately affects adults and remains exceedingly rare in infancy. However, Meckel's diverticulitis clinical symptoms are non-specific and frequently resemble other common acute surgical and inflammatory conditions of the abdomen. The infrequency and varied symptomatology make clear-cut pre-operative diagnosis of diverticulitis extremely challenging. We hereby, report a case of a six month old infant with acute diverticulitis who present with brief history of vomiting, abdominal distension and fever. Basically, our report is aimed at forewarning clinicians to consider meckel's diverticulitis as a differential diagnosis when assessing children who present with acute abdominal pathologies.

**Key words:** Meckel's diverticulum, diverticulitis, acute appendicitis, infants, children, asymptomatic diverticulum, symptomatic diverticulum, diagnosis, surgical resection.

## INTRODUCTION

Meckel's diverticulum essentially refers to an embryological remnant that is attributable to the failure of the omphalomesenteric duct to obliterate during the fifth to seventh week of fetal development (Seth and Seth, 2011).

Its embryological origin was initially described in fair details by the German anatomist Johann Friedrich Meckel about two hundred years ago, bolstering the earlier account of this congenital anatomic variant by Fabricius Hildanus, Levator and Ruysch between the 16 and 17th centuries (Seth and Seth, 2011; Malik et al.,

2010; Mohiuddin et al., 2011; Sagar et al., 2006). Meckel's diverticulum is a true intestinal diverticulum possessing all three coats of the intestinal wall with its separate blood supply from the vitelline artery. Having its own blood supply renders it susceptible to obstruction and infection (Seth and Seth, 2011; Malik et al., 2010; Mohiuddin et al., 2011; Sagar et al., 2006).

Meckel's diverticulum is invariably situated at the antimesenteric border of the distal ileum about 50 to 100 cm proximal to ileocecal valve (Seth and Seth, 2011; Malik et al., 2010; Mohiuddin et al., 2011; Sagar et al.,

\*Corresponding author. E-mail: uledi68@hotmail.com. Tel: (+265)999654403. Fax: +265 131 2123.

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2006; Coulier et al., 2003). Presence of the diverticulum up to 180 cm from the ileocaecal valve has been reported (Madhyastha et al., 2007). Meckel's diverticulum is estimated to occur in two percent of the general population and this makes it the most common congenital anomaly of the gastrointestinal tract (Seth and Seth, 2011; Malik et al., 2010; Mohiuddin et al., 2011; Sagar et al., 2006; Coulier et al., 2003; Madhyastha et al., 2007).

Typically Meckel's diverticulum remains asymptomatic and incidentally encountered during surgery, laparoscopic examination, small bowel contrast examination or at autopsy (Malik et al., 2010; Sagar et al., 2006). About fifty percent of Meckel's diverticulum contains ectopic or heterotopic tissues, commonest being gastric mucosa or pancreatic tissue which makes it more predisposed to complications (Seth and Seth, 2011; Malik et al., 2010; Mohiuddin et al., 2011; Sagar et al., 2006; Coulier et al., 2003; Madhyastha et al., 2007; Robijn et al., 2007). A variety of Meckel's diverticulum adverse outcomes have been reported in pediatric population, these include gastrointestinal haemorrhage, intestinal obstruction, intussusceptions and diverticulitis (Sagar et al., 2006; Dumper et al., 2006; Zahraa et al., 2003).

However, occurrence of diverticulitis in infancy remains a very rare clinical presentation and indeed poses a diagnostic dilemma (Seth and Seth, 2011; Malik et al., 2010; Mohiuddin et al., 2011; Sagar et al., 2006; Coulier et al., 2003; Madhyastha et al., 2007; Robijn et al., 2007; Dumper et al., 2006; Zahraa et al., 2003). Manifestation of Meckel's diverticulitis in infancy is highly likely to mimic other common acute surgical and inflammatory conditions of the abdomen (Sagar et al., 2006; Dumper et al., 2006; Zahraa et al., 2003).

This may lead to diagnostic and management delays. We herein, report a case of a six month old infant with acute diverticulitis. Our report is primarily intended to serve as a cautionary supplication to clinicians in our setting to consider Meckel's diverticulitis as a differential diagnosis when evaluating children who present with undifferentiated acute abdominal pain.

## CASE REPORT

Previously healthy six month old male infant weighing 7.6 kg was brought to our emergency department by his mother with short history of persistent vomiting, abdominal distension and fever for about seven hours duration. Mother reports that the baby was relatively well until about seven hours prior to admission when he started vomiting. It was non-projectile bilious vomiting, vomitus mainly consisted of watery yellowish fluid moderately bile stained and odorless.

The baby is reported to have vomited seven times prior to admission. There was no concomitant history of haematemesis, passing mucus or melena stools. During the same span of time the baby developed abdominal

distension and high grade fever punctuated with spells of rigors.

Associated with the aforementioned symptoms mother reports that the baby became irritable, cried excessively and was refusing to be breast fed. However, there was no history of twitching or convulsions and mother gave no history of trauma preceding the onset of symptoms.

Furthermore, mother reports to have attended antenatal clinic on regular basis during her pregnancy; her entire antenatal course was uneventful and the baby was born at the hospital setting; and mode of delivery was spontaneous vaginal delivery. Since birth, the baby has had excellent developmental milestones and by then he had received all the required vaccinations.

On examination, major findings were on the abdominal examination; however, on general examination we saw a baby boy, in good nutritional status, but ill looking, lethargic, irritable, crying excessively, febrile (38.7°C), moderately dehydrated, not pale and not jaundiced. He had a pulse rate of 132 beats per minute, regular with good volume; his blood pressure was 90/60 mmHg.

Per abdomen examination revealed moderately and uniformly distended abdomen which was not moving with respiration. The abdomen was rather rigid with marked tenderness on the right iliac fossa. There was noticeably rebound tenderness on the same site.

However, there was no obvious palpable mass or organomegaly. Tympanic note was elicited on percussion. Bowel sounds were significantly diminished. Digital rectal examination revealed normal findings with normal coloured stool on the glove.

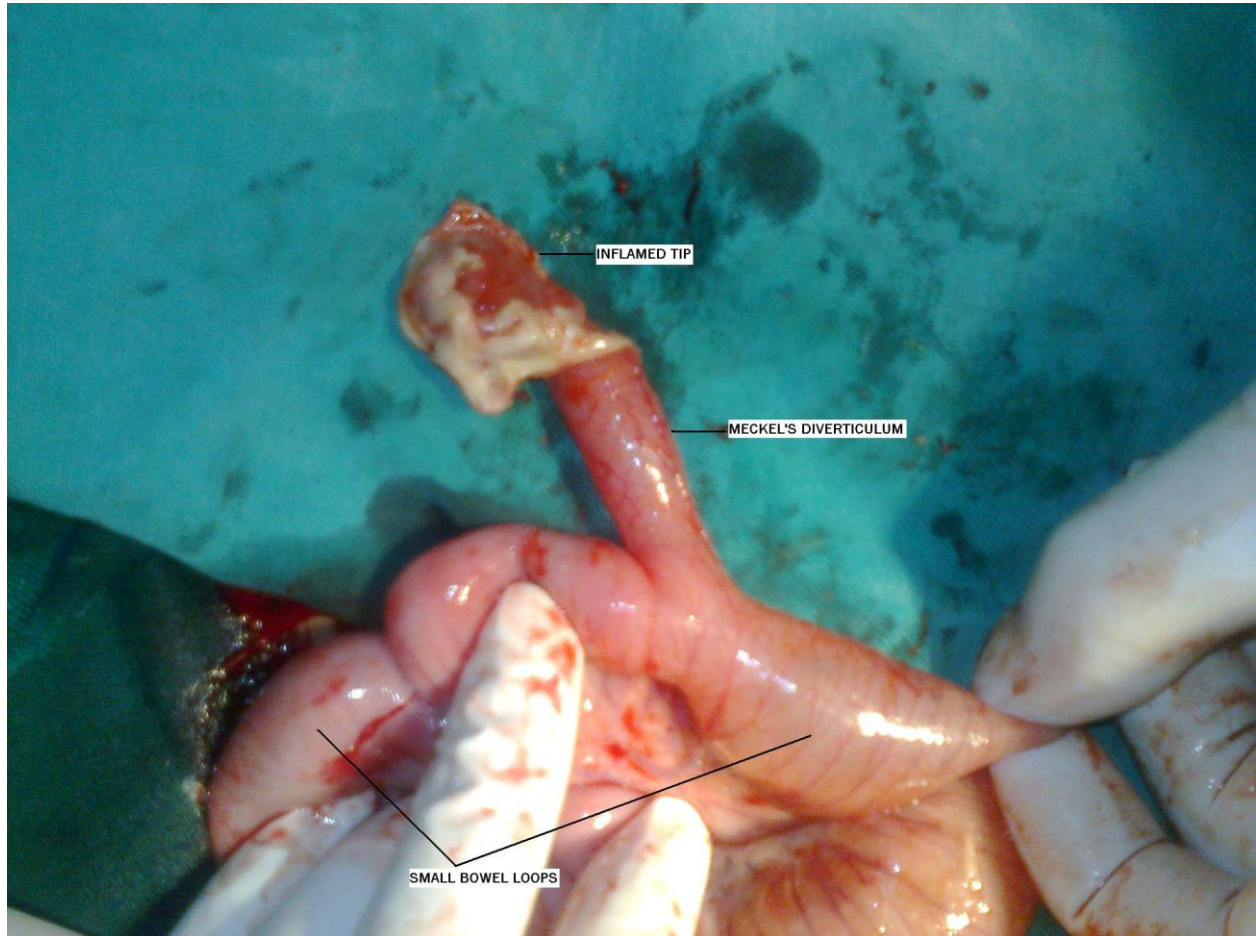
On respiratory system, the baby had mildly grunting respirations; however, he had no inter-costal or sub-costal recessions, and was not cyanotic. He had respiratory rate of 27 breaths/min. Chest was symmetrical, moving with respiration. He had normal breath sounds bilaterally with minimal transmitted sounds. The rest of systemic examination had nil of note.

Work-up of the patient comprised of radiological, biochemical and hematological profiles. The baby had complete blood count (CBC), serum electrolytes, malaria rapid diagnostic test (MRDT), blood grouping and cross matching, abdominal ultrasonography, as well as plain abdominal X-rays done. CBC revealed significant leukocytosis, whereas serum electrolytes showed mild hypokalemia. MRDT was negative.

Plain abdominal radiograph showed paucity of gas within the bowels, but there was no clear evidence of intestinal obstruction, pneumoperitoneum or pneumatosis intestinalis. Abdominal ultrasonography showed moderate amount of fluid in the right lower abdominal quadrant with dilated loops of small intestine.

Therefore in view of the history, physical examination and investigations, a diagnosis of peritonitis secondary to acute appendicitis was made.

Cognizant of rapidly deteriorating clinical signs and peritoneal irritation, the baby was urgently resuscitated



**Figure 1.** Intra-operative view shows very long Meckel's diverticulum on the antimesenteric border of the ileum with severely inflamed oedematous tip.

and informed written consent obtained from the mother. There after the baby was taken to the operating room for emergency surgery. Laparotomy was performed, through an infra-umbilical transverse incision which revealed moderately distended small bowel loops matted together and soiled with pus debris, there was significant presence of pus-stained peritoneal fluid collections in the pelvic cavity. After brief meticulous search, a long severely inflamed out-pouching structure arising from the antimesenteric border of the lower ileum was noted as a locus of infection. This was unquestionably an acutely inflamed Meckel's diverticulum situated about 47 cm proximal to ileocaecal valve.

It had a swollen oedematous tip with clear signs of severe inflammation. There was no discernible mass at the base of the diverticulum. The diverticulum was about 11 cm long, and had a caliber of about 2.3 cm (Figure 1). Of note was a very normal looking para-caecal appendix.

Macroscopically, other contiguous peritoneal viscera appeared normal. Thus, a short segment of ileum containing the diverticulum was resected in a wedge fashion and double layered end-to-end anastomosis was

successfully done. Patient had smooth postoperative recovery and was discharged home five days later.

Our intra operative findings were avowed by histopathology examination results which revealed features consistent with inflamed Meckel's diverticulum. However, there was no evidence of abnormal mucosa or underlying malignancy. Follow-up visit one year after surgery the baby was found to be in excellent condition.

## DISCUSSION

Meckel's diverticulum may remain asymptomatic throughout life time and incidentally discovered at autopsy. Meckel's diverticulum symptomatology principally arises from complications (Malik et al., 2010; Sagar et al., 2006; Robijn et al., 2007; Dumper et al., 2006). An inventory of potential complications that could arise from Meckel's diverticulum is long and heterogeneous.

These include perforation, haemorrhage, obstruction; intussusceptions, diverticulitis, axial torsion; foreign bodies' impactions and occurrence of neoplasm in the

diverticulum just to mention a few (Malik et al., 2010; Sagar et al., 2006; Robijn et al., 2007; Dumper et al., 2006; Zahraa et al., 2003).

Lifetime risk of complications from Meckel's diverticulum is projected to be at four percent by most series (Malik et al., 2010; Sagar et al., 2006; Robijn et al., 2007; Dumper et al., 2006; Zahraa et al., 2003). The most commonly encountered complication of Meckel's diverticulum in pediatric population is gastrointestinal haemorrhage which is highly ascribable to the presence of ectopic gastric or pancreatic mucosa. Occurrence of diverticulitis in infancy such as in our report remains rather a rare clinical manifestation (Malik et al., 2010; Sagar et al., 2006; Robijn et al., 2007; Dumper et al., 2006; Zahraa et al., 2003).

Contrary to many other acute abdominal conditions whereby detailed history, physical examination coupled with appropriate investigations often lead to correct diagnosis. Meckel's diverticulitis clinical symptoms are non-specific, wide-ranging and largely mirror a number of common acute surgical and inflammatory conditions of the abdomen such as acute appendicitis, peptic ulcer disease or biliary colic (Malik et al., 2010; Sagar et al., 2006; Robijn et al., 2007; Karatepe et al., 2009).

The rarity and varied symptomatology very often poses a diagnostic quandary. Accurate preoperative diagnosis of symptomatic Meckel's diverticulum is quite rare. In clinical practice the final diagnosis is mostly made at surgery (Malik et al., 2010; Sagar et al., 2006; Robijn et al., 2007; Karatepe et al., 2009).

Choice of investigations for Meckel's diverticulum largely depends upon patient's presentation and clinician adequate knowledge of its anatomical and pathophysiological dynamics. Frequently, a panel of investigations may be employed. Apart from biochemical and hematological work-up, various imaging techniques come into play. These ranges from plain abdominal X-rays, barium studies, arteriography, computed tomography (CT) scan, radionuclide scintigraphy and ultrasonography (Malik et al., 2010; Sagar et al., 2006; Coulier et al., 2003; Mittal et al., 2008; Lee et al., 2009).

Generally, plain abdominal X-rays have limited role in the diagnosis of Meckel's diverticulum; however, plain radiograph can demonstrate features of small bowel obstruction or pneumoperitoneum in case of perforation. Presence of gas-filled viscus in the right iliac fossa or central abdomen may grant inkling to diagnosis (Malik et al., 2010; Mohiuddin et al., 2011; Sagar et al., 2006; Coulier et al., 2003).

To some extent good quality barium studies may be useful in detection of Meckel's diverticulum; usually a diverticulum is visualized as a tubular structure arising from the anti-mesenteric border of the distal ileum. However, enteroclysis has a relatively low yield and beset by limitations in emergency setting (Malik et al., 2010; Mohiuddin et al., 2011; Sagar et al., 2006; Coulier et al., 2003). Under experienced and skilled operator, ultraso-

nography is extremely handy non-invasive diagnostic tool for patients with suspected diverticulum (Malik et al., 2010; Sagar et al., 2006; Coulier et al., 2003).

Sonographic findings of an inflamed Meckel's diverticulum may grossly mimic features of acute appendicitis or gastrointestinal duplication. Presence of a tubular hyper echoic structure on sonography may be indicative of Meckel's diverticulum (Malik et al., 2010; Mohiuddin et al., 2011; Sagar et al., 2006; Coulier et al., 2003).

CT scan depicts an inflamed Meckel's diverticulum as a blind-ending pouch of variable size with mural thickening and surrounding mesenteric inflammation which is attached to the distal ileum rather than the caecum. Where applicable, use of contrast-enhanced CT may be employed (Malik et al., 2010; Sagar et al., 2006; Coulier et al., 2003). Akin to ultrasonography, CT scan is also able to rule out other potentially pathological conditions.

In paediatric age group, Technetium-99m ( $^{99m}\text{Tc}$ ) pertechnetate scintigraphy also referred to as Meckel's diverticulum scan is one of the most useful non-invasive diagnostic methods for the diagnosis of Meckel's diverticulum with heterotopic gastric mucosa.

The isotope has a very high predilection to concentrate in ectopic gastric mucosa. Meckel's diverticulum scan has a diagnostic sensitivity of about 85%, specificity of 95% and accuracy of about 90%. However, Meckel's scan is less accurate in adult population due to diminution of ectopic gastric mucosa within the diverticulum. Occasionally, Technetium-99m ( $^{99m}\text{Tc}$ ) pertechnetate scan may be enhanced or augmented by the use of pharmacological agents such as pentagastrin, somatostatin or  $\text{H}_2$  receptor blockers which tend to intensify isotope uptake by the gastric mucosa (Malik et al., 2010; Sagar et al., 2006; Mittal et al., 2008; Karatepe et al., 2009).

Angiography is another valuable investigation that may be employed in the assessment of an adult patient with suspected bleeding from Meckel's diverticulum. The technique is effective in pinpointing the exact site of bleeding and occasionally used for therapeutic pre-operative embolization (Malik et al., 2010; Sagar et al., 2006; Lee et al., 2009).

In the advent of minimally invasive surgery, use of laparoscopy in patients with enigmatic presentations is preferred. Laparoscopy could be suitably utilized for both diagnostic and therapeutic purposes (Malik et al., 2010; Sagar et al., 2006; Robijn et al., 2007; Dumper et al., 2006; Zahraa et al., 2003; Lee et al., 2009).

Treatment of complicated or symptomatic Meckel's diverticulum has always been exclusively surgical resection either by conventional approach, that is, open surgery or through contemporary minimally invasive techniques. Usually resection span from simple diverticulectomy to segmental ileal resection.

Principally, resection is aimed at removal of Meckel's diverticulum, all ectopic gastric mucosa, or any ulcerated

adjacent ileal mucosa (Seth and Seth, 2011; Malik et al., 2010; Sagar et al., 2006; Robijn et al., 2006).

For instance, when the diverticulum base is fairly narrow then simple transverse diverticulectomy may suffice, whereas in short broad based diverticulum with ectopic gastric mucosa, inflammation, edema formation, ischaemic process, perforation, ulceration or haemorrhage, segmental ileal resection bearing the diverticulum followed by end to end anastomosis is warranted. Wide intestinal resection together with the affected mesentery lymphatics is recommended in case of suspected tumor involvement (Malik et al., 2010; Sagar et al., 2006; Robijn et al., 2006; Karatepe et al., 2009). Where feasible, certainly is a good practice to carry out histopathology examination for all resected diverticulum specimens.

Management of asymptomatic or incidentally found Meckel's diverticulum at laparotomy presents a distinctive and an outstanding challenge. Hitherto, asymptomatic or incidentally found Meckel's diverticulum treatment is shrouded in protracted controversy. The central theme being varied opinions from literature on management approaches towards the incidentally found Meckel's diverticulum; some authors recommend diverticulectomy in all encountered cases, others advise prophylactic resection only in the presence of risk factors, whereas the rest suggest that incidentally found Meckel's diverticulum should not be operated at all (Malik et al., 2010; Sagar et al., 2006; Robijn et al., 2006).

By far there is no universally agreeable treatment protocol with regard to asymptomatic or incidentally found Meckel's diverticulum. Indubitably, there is great need for a prospective large-scale multi-center randomized control clinical trial which might cast more light on this long standing contentious subject.

## Conclusion

Diverticulitis is one of the most common complications of Meckel's diverticulum, but remains rather rare in pediatric age group. The infrequency and diversity of its symptoms makes a precise pre-operative diagnosis of diverticulitis extremely challenging. Diagnostic stalemate may lead to interventional delays and subsequently life-threatening complications. Thus, sufficient knowledge of its pathophysiological dynamics, high index of suspicion and swift surgical intervention are of paramount importance in preventing morbidity and mortality associated with complications of this disease entity.

## Conflict of Interest

Authors declare no conflict of interest.

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