Typhoid ileal perforation in Shisong, Northwestern Cameroon

Bamidele Johnson Alegbeleye

Department of Surgery, St Elizabeth Catholic General Hospital, Shisong, Cameroon

*Corresponding Author: Dr. Bamidele Johnson Alegbeleye B.Sc (Hon.), M.B;B.S(Ib), MMCS, Ph.D, Department of Surgery, St Elizabeth Catholic General Hospital, Shisong, P.O Box 8, Kumbo - Nso, Bui Division, Northwestern Region, Cameroon, Tel: +237-670628857; Email: drbalegbeleye@gmail.com

Received Date: Feb 27, 2019 / Accepted Date: Mar 19, 2019 / Published Date: Mar 21, 2019

Abstract

Background: The study aims to provide an overview of the spectrum of perforated typhoid fever cases and their outcome that were managed in resource constrained rural mission hospital, Northwestern of Cameroon.

Methods: This was a retrospective observational study which was conducted in St Elizabeth Catholic General Hospital, Shisong, Northwestern region of Cameroon over a two year period covering January 2016 and December 2018. The patients included were those admitted and diagnosed of typhoid ileal perforation. Data collected were analyzed using SPSS computer software version 22.

Results: During the study period, thirty-eight patients underwent surgery for typhoid ileal perforation. They included 26 (68.43%) males and 12 (31.57%) females with Male to Female ratio of 2.2:1. Sixty-two percent of cases occurred between the months of July and September. The most common presentations were with abdominal pains (92.11%), and abdominal distention (92.11%). X-ray abdomen revealed pneumoperitoneum in 26 (68.4%) cases, while ultrasound detected free peritoneal collection in 34 (90%) cases. Perforations were surgically treated depending upon the number of perforations, general health status of patient and degree of fecal contamination. Perforated typhoid still carries dismal prognosis. The mortality was associated with duration of delay in obtaining blood pre-operatively for patients requiring transfusion (p=0.018) and duration of presentation to operation time interval (p=0.026).

Conclusion: Typhoid intestinal perforation is still endemic in our setting with dismal prognosis. Urgent public health concerted effort is required with emphasis on preventive measures such as safe drinking water, appropriate sewage disposal, and typhoid vaccination. Educating the populace on early and prompt diagnosis, adequate resuscitation as well as early surgery in patients with typhoid ileal perforation to keep the mortality low.

Keywords: Typhoid Fever; Ileal Perforation; Surgical Management; Outcome; Cameroon

Introduction

Typhoid fever is a multi-systemic febrile illness which is transmitted by ingestion of food or water contaminated with the typhoid bacillus [1,2]. The causative agent being the gram-negative bacillus, salmonella enteritidis, serovar typhi [1,3]. Historically, the pathology of the disease was first described by William Jenner in 1850 [4] and since then typhoid fever
remains a major public health concern in the developing countries like Nigeria, Cameroon etc. This is mainly because of its persistent high morbidity and mortality; especially in rural communities where poverty, ignorance and lack of adequate potable water supply remain the order of the day [5,6]. Typhoid is endemic in many rural and urban communities of the developing countries where the disease occurs throughout the year [5,6]. The most lethal complications of typhoid fever are intestinal bleeding and ileal perforations, both arising from necrosis of Peyer’s patches in the terminal ileum [7]. Typhoid ileal perforation is a serious complication of typhoid fever. It is also a significant challenge to surgeons in the developing countries [8-14]. Many factors such as late presentation, adequate pre-operative resuscitation, delayed operation, the number of perforations and extent of fecal peritonitis have been found to have a significant effect on the prognosis [15-19]. The burden of typhoid disease remains a major concern to clinicians globally over the last thirty years due to the unabating menace it causes the victims in spite of improving therapeutics and surgical techniques. The enormity of the challenges faced in the care of such patient was described by Irabor et al in 2003 as a milestone around the Surgeon’s neck or a complex sea of trouble [20,21]. Enteric fever remains a scourge in most developing countries; this is attributable to the limited availability of potable water supply, poor personal hygiene and food handling, as well as indiscriminate disposal of human waste, all of which form a formidable nidus for transmission of the infective agent salmonella enteritidis, serovar typhi. Therefore, poverty and low socioeconomic status are common associated factors [31].

Typhoid fever is a protracted disease that includes bacteremia phase with fever and chills during the first week, wide spread reticulo-endothelial involvement with rash, abdominal pain and prostration in the second week, and ulceration of payer’s patches with intestinal bleeding and perforation during the third week. There are longitudinal ulcers on anti-mesenteric border, situated within 45 cm of ileocaecal valve in majority of patients [2,5,6]. Furthermore, the diagnosis and management of typhoid perforation can also be challenging particularly those occurring during pregnancy or in the puerperal period and extreme of ages [2]. The resulting peritonitis in such a seriously ill patient may be rapidly fatal unless it is treated promptly and vigorously [22]. Initially 100% death rate was reported for the perforation [23,24]. Nowadays, the mortality rate although decreasing, still remains very high ranging from 15% to 39% in West African sub-region with significant morbidity in spite of therapeutic progress [25]. The improving clinical outcome in general is related to the availability of potent broad-spectrum antibiotics, improved methods of resuscitation, modern and safe anesthesia, surgery is now routinely used to manage ileal perforation and offers the best hope of survival [26]. There is paucity of data on the incidence, endemicity of typhoid fever, complications and outcome of management in all the local regions of Cameroon. Keeping this in view therefore, the study aims to provide an overview of the spectrum of perforated typhoid fever cases and their outcome that were managed in resource constrained rural mission hospital, Northwestern of Cameroon.

Patients and Methods

Study design and setting

This observational retrospective study was conducted in the Department of Surgery over a two-year period covering January 2017 and December 2018. The St Elizabeth Catholic General Hospital is located in Shisong -Kumbo, Northwestern region of Cameroon. It serves as a referral hospital for a teeming population of five million people from the geo-political zone.

Study population and procedure

We included in this study all patients operated on for generalized peritonitis for which a final
The diagnosis of perforated typhoid ileitis was made. The diagnosis of typhoid ileal perforation (or perforated typhoid ileitis as variably called) was made on the basis of patients’ typical clinical presentations supported by radiological, laboratory investigations and confirmed by operative and histopathological findings. The exclusion criteria were the following:

i. All the other causes of peritonitis such as ruptured appendix, traumatic perforations, tuberculosis enteric perforations, perforated peptic ulcer e.t.c, were excluded from the study.

ii. All patients with suspected peritonitis due to perforated typhoid ileitis for whom a laparotomy was not performed.

iii. All patients whose case file did not contain follow-up data.

Data source included admission registers of the emergency department, patient’s admission files, post-operative note registers and report books of the surgical wards. For each patient included, we recorded on a pre-validated proforma designed for this study regarding patient’s characteristics, to include demographic details, clinical features, past medical history, interval between onset of symptoms and hospital admission, operative findings, procedure performed, postoperative complications and duration of stay in hospital as well as the final outcome. The definition of sepsis, septic shock and multi-organ failure was according to the American College of Chest Physicians/Society of Critical Care Medicine Consensus Conference Committee of 1991 as modified in 2001 [27,28]. While the Clavien-Dindo classification was used to determine severity of complications [29,30].

The patients included in the study were either typhi dot and/or blood culture positive as well as rising widal titer. Detail history and documentation of source of water supply, sewage disposal system and environmental hygiene of confirmed cases were routinely collected in the center. All the patients were resuscitated with intravenous fluids, nasogastric tube to decompress the stomach and urethral catheter to monitor urine output. Adequate resuscitation was achieved within 6-10 hours of admission in 95% of patients. Intravenous antibiotics comprising ceftriazone, quinolones, and metronidazole were commenced immediately while gentamycin was added post-operatively, as well as blood transfusion as appropriate. The investigations carried out were full blood count, erythrocyte sedimentation rate (ESR), widal test, typhi dot, blood culture, blood urea, blood sugar, serum electrolytes, plain abdominal and chest radiographs as well as abdomino-pelvic ultrasound scan. The diagnosis of typhoid perforation was made by above investigations and on clinical grounds of abdominal pain, distension, tenderness, and confirmed by radiographic findings of pneumoperitoneum or air under the diaphragm. Also, diagnosis was further supported by operative findings of ileal perforation, and on acutely inflamed and edematous terminal ileum with associated peritoneal soiling. After resuscitation all patients under full general anesthesia were subjected to exploratory laparotomy within 24 hours. Laparotomy was performed by a midline incision; general survey of the peritoneal cavity was made. All pyogenic membrane carefully removed and residual fecopurulent material was aspirated from the peritoneal cavity. After dealing with the perforation, the peritoneal cavity was thoroughly washed with copious amount of normal saline and drains were kept in the pelvis. Abdomen was closed by mass closure technique with prolene size 1 and skin was closed with interrupted size 2/0 prolene. Post-operatively patients were kept nil by mouth till return of bowel sounds and at that time nasogastric tubes were removed. Parenteral antibiotics were continued for about one week. Drains were removed on 7th post-operative day. The variables studied in the post-operative period were wound infection, wound dehiscence, enterot-cutaneous fistula, residual abscess, mortality, hospital stay and incisional hernia.
Statistical Analysis

All data were entered in an excel database (Excel 2007, Microsoft corporation®) and analyzed using the Statistical Package for the Social Sciences (SPSS) version 22 (IBM Corp, Armonk, NY, USA). Absolute numbers and simple percentages were used to describe categorical variables. Similarly, quantitative variables were described using measures of central tendency mean and measures of dispersion such as range or standard deviation as appropriate. The associations between patient characteristics and mortality using Pearson and two-sample Wilcoxon test were carried out by using R version 2.10.1. A p-value <0.05 was considered statistically significant.

Ethical Considerations

Ethical approval was obtained from the Institutional Ethical Committee. Confidentiality was ensured by not writing the names of patients on proforma.

Reporting

The STROBE guidelines were used in reporting this study [31].

Results

Patient’s characteristics

A total of 56 patients were admitted in the institution with the clinical diagnosis of generalized peritonitis secondary to perforated typhoid ileitis over the study period between January 2016 and December 2018. Twelve records had incomplete data. These included six patients with a presumptive diagnosis of perforated typhoid ileitis who died before a laparotomy could be performed. In the final analysis therefore, thirty-eight patients had post-operative diagnosis of typhoid ileal perforation. Our samples included 26 (68.43%) males and 12 (31.57%) females with the Male to Female ratio is 2.2:1. The age range was 12 to 55 years with a mean of 24.43 years±SD 10.21 years). Majority of patients were in the second and third decades. (Table 1). Sixty-five percent of cases occurred between the months of July and September.

| AGE (YEARS) | NUMBER (n=38) | PERCENTAGE |
|-------------|---------------|-------------|
| <10         | 0             | 0           |
| 10-19       | 9             | 23.68       |
| 20-29       | 18            | 47.37       |
| 30-39       | 6             | 15.79       |
| 40-49       | 3             | 7.89        |
| >50         | 2             | 5.27        |
| TOTAL       | 38            | 100         |

Characteristics of the perforated typhoid ileitis

Most of the patients presented with abdominal pains (92.11%), abdominal distention (92.11%), nausea and vomiting (81.58%), constipation (56.3%) diarrhea (55.26%) and fever (52.63%) (Table 2). Most of the patients presented more than 24 h after the onset of peritonitis and some as late as 96 h. Mean duration of fever before presentation was 8 days (Range 3-14 days). Mean duration of abdominal pain was 5.2 days (Range 2-11 days). Mean temperature was 101.8°F (Range 99.5-103°F). Pulse rate ranged between 102-140 beats per minute with a mean pulse rate of 118. Widal test >1:320 was positive in 32 (84.2%) cases and typhi dot (IgM in all cases and IgG in 18) was positive in all cases. Blood culture was positive in 28 (73.7%) cases. X-ray abdomen revealed pneumoperitoneum in 26 (68.4%) cases. Ultrasound detected free peritoneal collection in 34 (90%) cases, hypokalemia was found in 10 (26.3%) cases. Blood complete picture revealed leucocytosis in 13 (34%) patients while total leucocyte count was normal in 20 (53%) patients with raised ESR ranging from 48 to 74 mm of Hg in the first hour. Stool culture was done in 22 (58%) patients, but was only positive.
Typhoid ileal perforation in shisong, northwestern cameroon

OSJS: Volume 1: Issue 1, March-2019: Page No: 08-24

in 8 patients. All the patients had HIV tests done routinely and none in our series was positive.

Table 2: Clinical features of patients with typhoid ileal perforation.

| CLINICAL FEATURES | NUMBER OF PATIENTS (n=38) | PERCENTAGE |
|-------------------|---------------------------|------------|
| Fever             | 20                        | 52.63      |
| Abdominal pain    | 35                        | 92.11      |
| Abdominal distention | 35                  | 92.11      |
| Diarrhea          | 21                        | 55.26      |
| Nausea and Vomiting | 31                    | 81.58      |
| Constipation      | 22                        | 57.89      |

Operative findings were; abdominal cavity heavily contaminated in 25 (65.78%) patients while in 13 (34.22%) patients the peritoneal cavity was found in a comparatively better condition. 25 (65.78%) patients had single perforation and 13(34.22%) had more than one perforation. In all cases perforations were within the last 50 cm of ileum. Perforations were surgically treated depending upon the number of perforations, general health status of patient and degree of fecal contamination. In 28 (73%) patients’ perforations after freshening the ulcer were closed by double layered interrupted sero-muscular technique with vicryl 2/0 and 3/0 prolene respectively. Four (11%) needed resection and anastomosis and in another 4 (11%) loop ileostomy was made while 2(4%) patients had limited right hemicolectomy.

Risk Factors Determination

Ten patients of 38 patients (26.3%) requiring pre-operative transfusion (i.e., hematocrit <30%) had a delay in obtaining necessary blood for transfusion before operation, which was defined as being greater than six hours. The mean duration of this delay was 14.2 ± SD 10.8 hours. Using the Pearson test for univariate analysis statistically -significant associations with mortality were found with gender (p=0.008), presence of neurological manifestation upon presentation (delirium, seizure or loss of consciousness) (p=0.012), and delay in securing blood pre-operatively for patients requiring pre-operative transfusion (p=0.018) (Table 3). No associations were found between mortality and any other sign or symptom besides neurological manifestations, or receiving pre-presentation treatment of any type. When the two -sample Wilcoxon test for univariate analysis, was used; the associations with mortality were found to be statistically -significant for duration of delay in obtaining blood pre-operatively for patients requiring transfusion (p=0.018) and duration of presentation-operation time interval (p=0.026) (Table 4-6). The mean time interval between presentation and operation was 15.0±SD 11.6 hours in those who died and 20.0±SD 8.9 hours in those who survived. The median delays in obtaining blood were 18.5±SD 9.6 hours for those with a delay who died and 11.4±SD 7.5 hours for survivors who had a delay. We did not observe any statistically significant difference in mortality rates for those patients with initial symptoms to presentation, as well as other factors like age, vital signs, duration of any sign or symptom and hematocrit or white blood cell count.

Outcome

The outcome data are shown in Table 5 and 6. The complications were wound infection in 12 patients (31%), wound dehiscence in 10 patients (26%), and intra-abdominal abscess in 4 patients (11%), enterocutaneous fistula in 6 patients (16%). In this series there were 6 (16%) deaths. Sixteen (42%) patients developed incisional hernia. In 6 patients, in whom loop ileostomy and limited hemicolectomy was made stoma related complications like stomal prolapse in 3 (50%) patients, retraction in 2 (33%) patients, bleeding in 1 (17%) patients.
and skin excoriation was seen in 6 (100%) cases. Mean hospital stay was 15.46 days ranging from 10 to 45 days.

**Table 3: Assessing the associations between risk factors and mortality. (nominal variables)**

| RISK FACTOR                                      | NUMBER OF PATIENTS (n) | SURVIVED (n=32) | DIED (n=6) | P-VALUE |
|--------------------------------------------------|------------------------|-----------------|------------|---------|
| Any Pre-presentation treatment                   | 38                     | 25              | 5          | 0.68    |
| Female Gender                                    | 12                     | 8               | 4          | 0.012   |
| Presence of Abdominal Distension                 | 35                     | 28              | 6          | 0.45    |
| Presence of Abdominal Pain                       | 35                     | 29              | 6          | 0.36    |
| Presence of Constipation                          | 22                     | 18              | 4          | 0.41    |
| Presence of Diarrhea                              | 21                     | 18              | 14         | 0.54    |
| Presence of Fever                                 | 20                     | 14              | 6          | 0.33    |
| Presence of Neurological deficits                 | 18                     | 8               | 2          | 0.012   |
| Presence of Vomiting                              | 31                     | 28              | 16         | 0.82    |
| Presence of abnormal bowel sounds (hypoactive sounds) | 26                   | 21              | 5          | 0.22    |
| Pre-operative blood procurement delay             | 10                     | 8               | 4          | 0.018   |

**Table 4: Assessing the associations between risk factors and mortality. (continuous variables).**

| RISK FACTOR                                      | NUMBER OF PATIENTS (n) | SURVIVED (n=32) | DIED (n=6) | P-VALUE |
|--------------------------------------------------|------------------------|-----------------|------------|---------|
| Age (years)                                      | 6                      | 6               | 6          | 0.48    |
| Blood Pressure -Diastolic (mmHg)                  | 72                     | 74              | 62         | 0.09    |
| Blood Pressure -Systolic (mmHg)                   | 120                    | 115             | 110        | 0.66    |
| Duration of Abdominal Distension (days)           | 2                      | 1               | 3          | 0.75    |
| Duration of Abdominal Pain (days)                 | 5                      | 5               | 5          | 0.62    |
| Duration of Constipation (days)                   | 4                      | 4               | 4          | 0.28    |
| Duration of Diarrhea (days)                       | 3                      | 4               | 4          | 0.70    |
| Duration of fever (days)                          | 7                      | 7               | 10         | 0.88    |
| Duration of Vomiting (days)                       | 2                      | 1               | 3          | 0.34    |
| Duration of pre-operative blood delay (hours) (n=10, 4, 6 patients) | 10                   | 8               | 4          | 0.018   |
| Duration of Presentation-Operation interval (hours) | 14                   | 15              | 20         | 0.026   |
| Hematocrit (%)                                    | 30.5                   | 32              | 29.5       | 0.56    |
| Initial symptom to presentation our hospital interval (days) | 10                   | 10              | 10         | 0.44    |
| Pulse (Beats per Minute)                          | 90                     | 88              | 110        | 0.21    |
| Temperature (°Celsius)                            | 38                     | 38.2            | 39         | 0.67    |
| White Blood Cell Count (x 10⁹/Liter)              | 9.2                    | 8.2             | 7.0        | 0.46    |
**Table 5:** Post-operative complications.

| FACTOR                  | FREQUENCY (n= 38) | PERCENTAGE |
|-------------------------|-------------------|------------|
| POST OP COMPLICATION    |                   |            |
| Infection               | 12                | 31         |
| wound dehiscence        | 10                | 26         |
| Intra-abdominal abscess | 4                 | 11         |
| fistula                 | 6                 | 16         |
| OUTCOME                 |                   |            |
| Discharged              | 32                | 84         |
| Death                   | 6                 | 16         |
| DAMA                    | 0                 | 0          |
| Total                   | 38                | 100        |

**Table 6:** Comparing the outcome with: the duration of illness; use and type of medication before presentation; and number of perforations.

| OUTCOME                  | DISCHARGED | DIED | DAMA | TOTAL | P VALUE |
|--------------------------|------------|------|------|-------|---------|
| DURATION OF ILLNESS: a   |            |      |      |       |         |
| <1week                   | 4          | 1    | 0    | 5     |         |
| 1-2weeks                 | 18         | 3    | 0    | 21    | 0.419   |
| >2weeks                  | 10         | 2    | 0    | 12    |         |
| Total                    | 32         | 6    | 0    | 38    |         |
| USE OF MEDICATIONS: b    |            |      |      |       |         |
| Orthodox                 | 22         | 3    | 0    | 25    | 0.751   |
| Traditional              | 10         | 3    | 0    | 13    |         |
| Total                    | 32         | 6    | 0    | 38    |         |
| NUMBER OF PERFORATIONS: c|            |      |      |       |         |
| 1                        | 25         | 1    | 0    | 26    |         |
| 2                        | 2          | 1    | 0    | 3     |         |
| 3                        | 2          | 1    | 0    | 3     |         |
| >3                       | 3          | 3    | 0    | 6     |         |
| Total                    | 32         | 6    | 0    | 38    | 0.058   |

DAMA=Discharged against medical advice.

**Discussion**

In this series we reported the highest incidence of perforation from typhoid disease compared to other health institutions in Cameroon followed by Buea and Yaoundé [32,33]. Although, the incidence of typhoid disease in Cameroon in general continue to rise yearly despite vigorous public health measures [32,33]. These generally apply to the entire nation of Cameroon where general public sanitation is poor and there is no proper controlled waste disposal systems. Most
people obtain their water supply from the public tap whenever available and individual household shadow wells [21]. The difference in our findings may be explained by the on-going anglophone crisis in the northwestern region of Cameroon; where many public social amenities have been destroyed due to war. Access roads in some instances to major referral health facilities are completely cut off; therefore impacting negatively on the overall public healthcare delivery system. Moreover, seasonal variations have been reported with two peak periods in the rainy and dry season, which is similar to findings in this study [34,35]; we recorded the highest numbers of new cases between July and September corresponding to the peak of rainy season also synonymous to pollution of the sources of major surface drinkable water in our rural communities. [34,35] Other literature did not report this seasonal variations [36].

Our results demonstrate that the current delays in the interval between hospital presentation and operation, as well delays in obtaining donated blood for transfusion, are associated with increased mortality in typhoid patients with intestinal perforation. Previous studies of patients with intestinal typhoid perforations have demonstrated statistically significant associations with pre-operative factors including female gender, presenting systolic blood pressure less than 90 mmHg, abdominal tenderness, prolonged time interval between presentation and operation [14,37], duration of abdominal pain [37,38], presenting temperature greater than 38.5°C [37,39]. We presume that the natural physiological demands in female patients such as menstruation, lactation, breastfeeding and pregnancy could be responsible for the physiological anemia and relative immune-compromise which inadvertently could increase the severity of typhoid in such patients and increased mortality in our study; there are similar reports on the etiopathogenesis of typhoid [2-4]. Interestingly, this is not the first time this type of association with female gender has been observed [14]. Typhoid psychosis which is characterized by neurological manifestations such as delirium, seizure or loss of consciousness is often associated with mortality therefore our findings of such neurological deficits are not unexpected [14,37,39]. These neurological manifestations also indicate severe sepsis or blood loss, and ultimately precede death for many medical conditions [14,37,39]. In our series, majority of the patients presented with anemia, in which their overall mean hematocrit of all the patients was 30.5%. There are reports by many authors, suggesting that typhoid is a multi-systemic illness therefore leads to anemia through bone marrow suppression, hemaphagocytosis, occasionally hemolysis, and intestinal hemorrhage [37,40]. The delays in procuring blood for pre-operative transfusion were major contributors to this delayed pre-operative interval. Some of the misconceptions being reported in literature that are associated with low donation rates include fear of contracting HIV or hepatitis from blood donation, weight-loss, sexual failure (reduced libido), high blood pressure, sudden death, and seizure etc., [41-43].In agreement with other reports, the clinical features of this disease as outlined in this study (Table 2) include fever, abdominal pains, abdominal distention and vomiting which have been relatively constant and render the disease readily recognizable at presentation [1,13,17,19]. Other features include anemia due to bone marrow depression and cardiovascular instability and toxic myocarditis with bronchopneumonia [30]. The rate of hemoperitoneum in this series was 68.4%, which is low compared to other series, which have up to 75% [14,38-40]. The value of the radiological investigation has been compared with other writers and with current radiological techniques; 70-90% of cases are correctly diagnosed. Findings from this study demonstrated free gas under the diaphragm on abdominal and chest radiographs in more than sixty-five percent of cases which is consistent with other studies [44-46]. A plain abdominal or chest radiograph with free air under the diaphragm is a fairly frequent but variable
finding signifying perforated hollow viscus, but its absence does not exclude the diagnosis as seen in figure 1. Abdominal ultrasonography has also been found to be superior to plain radiographs in the diagnosis of free intra-peritoneal air as confirmed by the present study [44-46]. Additional definitive diagnosis of typhoid fever is made with typhi dot, widal test, and blood culture which were positive in 100%, 84.2%, 73.7% of patients respectively. A rising titer of agglutinin (the Widal test) is usually diagnostic, but a single test may mislead, especially if the patient had previous typhoid vaccination. In this review, the single titer levels ranged from 1:160 - 1:640 with a mean of 1:320. Reports from the literature also suggest that the spectrum and frequency of complications remain largely the same over the last decade irrespective of surgical techniques and recent potent antibiotics [20, 47-49]. The mortality rates similarly remained relatively unchanged averaging 35% with others below 15% and this is corroborated by the mortality rate of 16% in this study [20,47-49].

**Figure 1:** Air under hemidiaphragm.

Furthermore, typhoid affects several organs including the heart, lungs, kidneys and intestinal tract [47-49]; mediated via endotoxin and/ or Swartzmann-Sanarelli type of hypersensitivity reaction [20,50-53] which is reportedly responsible for the ulceration of the payer’s patches and the ileal typhoid perforations as demonstrated in figure 2 [20,50-53]. Hence antibiotics are unable to prevent the complications of bleeding and perforation [20,50-53]. Therefore, lending credence to the aforementioned mechanism. According to reports from the other regions of the world, perforation rate ranges from 0.6% to 4.9% of enteric fever cases [54-58], but in West Africa, higher rates of 10%-33% have been reported [50-53]. In this review, the rate of typhoid intestinal perforation represented 11.5% of cases which is in agreement with that reported in Western Africa sub-region [19,57-60]. The high rate of intestinal perforation in this sub-region is related to a more virulent strain of Salmonella typhi among West Africans, coupled with increased hypersensitivity reaction in the Peyer’s patches. In the present study, the highest incidence of typhoid intestinal perforation occurred in the first and second decades of life which is in keeping with other studies done elsewhere [61-63]. The increasing occurrence of typhoid intestinal
perforation in this age group in our setting can be explained by the fact that youths are generally more adventurous and mobile as well as more likely to consume unhygienic food outside the home [61-63]. Another cause is connected to the high risk of fecal contamination as they visit the toilets at school or public toilets especially with improper hand hygiene [61-63]. It is important to emphasis the negative socio-economic impact of the burden of the disease to the nation especially because the economically productive age-group is mostly affected. This call for an urgent public policy response on preventive measures such as safe drinking water and appropriate sewage disposal, and typhoid vaccination [56,57,63].

Figure 2: Typhoid ileal perforation.

In agreement with other studies, typhoid intestinal perforation in the present study was more common in males than in females [19-62-66]. Even though, the exact reason for this male preponderance is unknown, it is possible that men have an increased risk of exposure to typhoid fever resulting from spending longer time and consuming more food outdoors which could account for more frequent contact with the causative bacteria and genetic predisposition also heightens the risk [62-66]. In a related development, typhoid ileal perforation has been reported to be more prevalent in people with low socio-economic status [63]. This observation is equally reflected in this series where majority of patients are farmers and therefore came from the rural areas of Kumbo in the Northwestern region of Cameroon. The month of September witnessed the highest numbers of typhoid ileal perforation in our study; this observation was comparable to those of Ugochukwu et al [67], Gupta et al [68] and Anyanwu et al [69] but in contrast to that of Ugwu et al [63] who documented more cases between November and March. Surgery remains the mainstay of treatment for typhoid ileal perforation; however, this will require efficient resuscitation and correction of deficits such as electrolyte derangements and shock before surgery. Early surgery may determine the outcome, especially following effective resuscitation. About 65% of our cases were operated on within 13-24 hours post-admission. Gupta et al [68] reported that early surgical intervention improves the prognosis. There are different surgical methods of repairing the perforation including primary closure, excision and closure, resection and primary anastomosis, limited right hemicolecctiony and ileostomy [70]. However, early daily diagnosis, prompt and adequate resuscitation and early treatment, avoid the need for extensive surgical procedure and is associated with low morbidity and mortality [71,72]. Late presentation results in extensive pathological changes in the terminal ileum and caecum and therefore requiring more formidable and extensive surgical procedure such as resection anastomosis and right hemicolecctiony all of which contribute to higher morbidity and mortality [73].

The choice of surgical technique is influenced by the severity of illness such as the number of perforations and the expertise of the surgeon. In our study, excision and simple closure was the most common procedure done; this observation was similar to that of Ugochukwu et al [67], and Edino et al [64]. This procedure is easy and less time-consuming, though the risk of postoperative fistula is higher; however, we reported 25 (65.78%) cases of single perforation. The number of perforations in our study ranged from one to six, which was similar to the one to eight reported by Anyanwu et al [69]. Single perforation was the most common
intraoperative observation in our study; this was similar to other reports [57,71-74].

Complications recorded were wound infection 31%, wound dehiscence 26%, and intra-abdominal abscesses 16% [19] as demonstrated in Table 3. The enterocutaneous fecal fistula and re-perforation (16%) recorded in this series were similar to other reports that suggests that late presentation is associated with these complications [15,19,74,75] as seen in Table 4. The degree of the surgical complications in this series was also presented using Clavien-Dindo classification [76] as shown in Figure 3. The mortality rate of typhoid ileal perforation ranged from 9% to 43% in the West African sub-region [19]. Consequently, a mortality rate of 16% was recorded in this study; this figure was similar to those of Adesunkanmi and Ajao [19] but higher than those of Edino et al [64] and the 10.9% reported by Anyanwu et al [69]. The reason for the high mortality is multifactorial. We observed from this study that late presentation, delay in diagnosis, and inappropriate or partial treatment of typhoid fever were the main causative factor. The majority of our patients were from the rural communities with a limited health infrastructure. In addition, the other contributory factor is the ongoing anglophone crisis that sometimes make transportation of ill patients so difficult and during such crisis some patients had to travel for days before accessing a secondary or tertiary healthcare facility.

**Figure 3:** Distribution of complications recorded in our patients according to the clavien -dindo classification.

![Figure 3: Distribution of complications recorded in our patients according to the clavien -dindo classification.](image)

**Conclusion**

Typhoid fever remains a serious public health problem in the developing countries with a devastating impact on resources-limited setting. The high mortality rate is still unacceptable despite some improvements in the last decade. Typhoid ileal perforation was almost invariably fatal but with development of newer broad-spectrum antibiotics, safe and modern anesthesia, surgery is now routinely used to manage ileal typhoid perforation and offers the
best hope of survival. Several modifiable factors observed in our study can be improved, this eventually could result in decreased mortality for typhoid patients. Lessons learnt from this study especially those relating to the risk determinants are adoptable to other clinicians in similar settings for improvement in outcome. Most importantly, future clinical research in this field should assess mortality in patients with intestinal perforation or other surgical emergencies before and after establishing interventions to reduce presentation to operation interval and delays in obtaining blood for transfusion. We also envisage that such interventions would definitely improve the overall outcome of patients requiring emergency abdominal operations in the Cameroon and Africa at large. In the meantime, there is an urgent public health concerted effort needed with emphasis on preventive measures such as safe drinking water, appropriate sewage disposal, typhoid vaccination. A clarion call is also made for an urgent resolution of ongoing Anglophone crisis; whereby many public social amenities have been destroyed due to war. Access roads in some instances to major referral health facilities are completely cut off; therefore, impacting negatively on the overall public healthcare delivery system. Finally, educating the populace on early and prompt diagnosis, adequate resuscitation as well as early surgery in patients with typhoid ileal perforation to keep the mortality low.

Limitations of The Study

1. Retrospective nature of the study with causal effect of missing data on the case files of some patients.
2. Lack of Electronic Medical Record System in the hospital in the past years until January 2018 with resultant loss of data.
3. Delay in patients’ presentation, and compounded by the on-going anglophone -crisis
4. Poverty, ignorance, and safe drinking water, inappropriate sewage disposal insufficient health infrastructure, in the sub-region of Cameroon are amongst the lists of possible limitations of this study.

Recommendations

1. Full implementation of Electronic Medical Record System in our local hospitals in the sub-regions for a comprehensive data base will support improved future research on the disease.
2. There is an urgent public health concerted effort needed with emphasis on preventive measures such as safe drinking water, appropriate sewage disposal, and typhoid vaccination.
3. Provision of public treated tap water and sinking of bore-hole water in remote communities.
4. Educating the populace on early and prompt diagnosis, adequate resuscitation as well as early surgery in patients with typhoid fever to keep the morbidity and mortality low.
5. Effective government legislation on hand hygiene, proper sewage and waste disposals.
6. Several modifiable factors observed in our study can be improved, this eventually could result in decreased mortality for typhoid patients especially those with bowel or intestinal perforation and those other patients requiring operations.
7. Lessons learnt from this study especially those relating to the risk determinants are adoptable to other clinicians in similar settings for improvement in outcome.
8. Future research in this area should assess mortality in patients with intestinal perforation or other surgical emergencies before and after establishing interventions to reduce presentation to operation interval and
delays in obtaining blood for transfusion.

9. Finally, a clarion call for early resolution of ongoing Anglophone crisis and in resource constrained setting as ours, it is also important to raise awareness through public health campaign on prevention of water-bored disease and improvement of existing health infrastructure.

Declarations

Availability of data and Materials: Availability of data and materials confirmed by the author and available for review by the Editor-in-Chief of this journal.

Authors’ Contributions: BJA conceived of the study and participated in its design and coordination as well as helped to draft the manuscript; the author also read and approved the final manuscript.

Ethics Approval and Consent to Participate: Ethical approval was obtained from the Institutional Ethical Committee. Confidentiality was ensured by not writing the names of patients on proforma. A copy of the written Approval is available for review by the Editor-in-Chief of this journal.

Consent for Publication: Written informed consent was obtained from the patients for publication of this clinical research study and any accompanying images. A copy of the written consents is available for review by the Editor-in-Chief of this journal.

References

1. Osifo OD, Ogiemwonyi SO. 2010. Typhoid ileal perforation in children in Benin City. Afr J Paediatr Surg. 7: 96-100. Ref.: https://bit.ly/2ueiVgc
2. Ansari AA, Naqvi SQH, Ghumro AA, et al. 2009. Management of typhoid ileal perforation: a surgical experience of 44 cases. 7: 27-30. Ref.: https://bit.ly/2JnriQP
3. Raffatellu M, Wilson RP, Winter SE, et al. 2008. Clinical pathogenesis of typhoid fever. J Infect Developing Countries. 2: 260-266. Ref.: https://bit.ly/2UHhtyt
4. Jenner W. 1850. On the identity or non-identity of typhoid and typhus fever. London.
5. Karmacharya B, Sharma VK. 2006. Results of typhoid perforation management: Our experience in Bir Hospital, Nepal.4: 22-24. Ref.: https://bit.ly/2WcomIx
6. Singh Y, Khakure M. 1998. Typhoid perforation in adults. Journal of Institute of Medicine. 20.
7. Hosoglu S, Aldemir M, Akalin S, et al. 2004. Risk Factors for Enteric Perforation in Patients with Typhoid Fever.160: 46-50. Ref.: https://bit.ly/2TWNlSs
8. Abantanga FA, Wiafe-Addai BB. 1998. Postoperative complications after surgery for typhoid perforation in children in Ghana.14: 55-58. Ref.: https://bit.ly/2Y4qhjZ
9. Gibney EJ. 1989. Typhoid perforation. 76: 887-889.
10. Welch JP, Martins NC. 1975. Surgical treatment of typhoid perforation. Lancet. 1: 1078-1080. Ref.: https://bit.ly/2W6A5Z6
11. Eggleston FC, Santoshi B. 1981. Typhoid perforation: choice of operation. 8: 341-342.
12. Chonhau MK, Pandu SK. 1982. Typhoid enteric perforation. 69: 173-175. Ref: https://bit.ly/2Jlp4RV
13. Ajao OG. 1981. Abdominal emergencies in a tropical African population. 8: 345-347. Ref.: https://bit.ly/2TJtF5P
14. Meier DE, Imiediegwu OO, Tarpley JL. 1989. Perforated typhoid enteritis: operative experience with 108
cases.157: 423-427. Ref.: https://bit.ly/2UMJAwP
15. Parry EHO. 1984. Typhoid fever. In: Parry E.H.O. (ed). Principles of medicine in Africa. 268-276.
16. Archampong EQ. 1976. Typhoid ileal perforation: why such mortality. 63: 317-321. Ref.: https://bit.ly/2UIOp6u
17. Olurin FO, Ajayi OO, Bohrer SP. 1972. Typhoid perforation. J Coll Surg Edinb. 17: 253-263.
18. Ajao OG. 1982. Typhoid perforation: factors affecting mortality and morbidity. Int Surg. 67: 317-319. Ref.: https://bit.ly/2HF9D1
19. Adesunkanmi ARK, Ajao OG. 1997. The prognostic factors in typhoid ileal perforation: a prospective study of 50 patients. J R Coll Surg Edinb. 42: 395-399. Ref.: https://bit.ly/2Htc7nh
20. Irabor DO. 2003. Fifteen years of Typhoid perforation in children in Ibadan: Still a milestone around the surgeon’s neck. The Nigerian Journal of Surgical Research. 5: 92-98. Ref.: https://bit.ly/2udQCP1
21. Grema BA, Aliyu I, Michael GC, et al. 2018. Typhoid ileal perforation in a semi-urban tertiary health institution in north -eastern, Nigeria, South African Family Practice. 60: 168 -173. Ref.: https://bit.ly/2TXRB44
22. Talwarr S, Sharmad A, Mittala IND, et al.1997. Typhoid enteric perforation. Aust N Z J Surg. 67: 351-353. Ref.: https://bit.ly/2Htbazi
23. Bikandou G, Dykoka R, Spun A, et al.1990. Les perforations intestinales d’origine typique a Brazzaville. Pub Med Afr. 120: 37-41.
24. Foster EC, Lefor AT. 1996. General management of gastro -intestinal fistulas: recognition, stabilization and correction of fluid and electrolyte balances. Surg Clin North Am. 76: 1019-1033. Ref.: https://bit.ly/2Odq1dL
25. Giesecke J. 2002. Modern infectious disease epidemiology. 2nd ed. Ref.: https://bit.ly/2UlhDoE
26. Nastani M, Sial I, Mal V. 1997. Typhoid perforation of small bowel: a study of 72 cases. J R Coll Surg Edinb. 42: 4-6. Ref.: https://bit.ly/2OeOuQg
27. Levy MM, Fink MP, Marshall JC, et al. 2003. SCCM/ESICM/ACCP/ATS/SIS. 2001 SCCM/ESICM/ ACCP/ATS/SIS International Sepsis Definitions Conference. 31: 1250-1256. Ref.: https://bit.ly/2TTgvO5
28. Bone RC, Balk RA, Cerra FB, et al. 1992. Definitions for sepsis and organ failure and guidelines for the use of innovative therapies in sepsis. The ACCP/SCCM Consensus Conference Committee. American College of Chest Physicians/Society of Critical Care Medicine. Chest. 101: 1644-1655. Ref.: https://bit.ly/2JnGWf1
29. Clavien PA, Barkun J, de Oliveira ML, et al. 2009. The Clavien -Dindo classification of surgical complications: five -year experience. Ann Surg. 250: 187-196. Ref.: https://bit.ly/2Y3GFRW
30. Mentula PJ, Leppäniemi AK. 2014. Applicability of the Clavien -Dindo classification to emergency surgical procedures: a retrospective cohort study on 444 consecutive patients. Patient Saf Surg. Ref.: https://bit.ly/2FeKevV
31. von Elm E, Altman DG, Egger M, et al. 2014. STROBE Initiative. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: guidelines for reporting observational studies. Int J Surg. 12: 1495-1499. Ref.: https://bit.ly/2TsShoT
32. Yao JG, Masso -Misse P, Ibile A, et al. 1994. Typhoid perforations: experiences in a surgical setting in Cameroon. Apropos of 49. 54: 242 -246. Ref.: https://bit.ly/2ObFdZd
33. Weledji EP, Lemoupa SM, Njunda A, et al. 2014. Typhoid perforation associated with rectal bleeding in HIV - infected patient. Gastroenterology and hepatology. 1: 11-15. Ref.: https://bit.ly/2UMNHbL
34. Meier DE, Tarpley. 1998. Typhoid intestinal perforations in Nigerian children. World J Surg. 22: 319-323. Ref.: https://bit.ly/2C15HT1
35. Lizzalde EA. 1981. Typhoid perforation of the ileum in children. J. Pediatr Surg. 16: 1012-1016. Ref.: https://bit.ly/2F4Z2gk
36. Keenan JP, Hadley GP. 1984. The surgical management of typhoid in children. Br. J Surg. 71: 928 -929. Ref.: https://bit.ly/2W8PxUy
37. Barnett BS, Tarpley MJ, Davidson MA, et al. 2017. Factors Associated with Perioperative Mortality In Typhoid Fever Patients with Intestinal Perforation in Nigeria. 1: 12 -16.
38. Nasir AA, Abdur -Rahman LO, Adeniran JO. 2011. Predictor of mortality in children with typhoid intestinal perforation in a Tertiary Hospital in Nigeria. Pediatr Surg Int. 27: 1317-1321. Ref.: https://bit.ly/2UMOXvv
39. Talabi AO, Etonyeaku AC, Sowande OA, et al. 2014. Predictors of mortality in children with typhoid ileal perforation in a Nigerian tertiary hospital. 30: 1121-1127. Ref.: https://bit.ly/2YdwIkW
40. Abro AH, Abdou AM, Gangwani JL, et al. 2009. Hematological and biochemical changes in typhoid fever. Pak J Med Sci. 25: 166-171. Ref.: https://bit.ly/2Fi4AW5
41. Emeribe AO, Ejele AO, Attai EE, et al. 1993. Blood donation and patterns of use in southeastern Nigeria. Transfusion. 33: 330-332. Ref.: https://bit.ly/2Y7I75R
42. Olaiya MA, Alakija W, Ajala A, Olatunji RO. 2004. Knowledge, attitudes, beliefs and motivations towards blood donations among blood donors in Lagos, Nigeria. Transfus Med. 14: 13-17. Ref.: https://bit.ly/2HAsf5X
43. Umeora OU, Onuoh SO, Umeora MC. 2005. Socio -cultural barriers to voluntary blood donation for obstetric use in a rural Nigerian village. Afr J Reprod Health. 9: 72-76. Ref.: https://bit.ly/2TW03kp
44. Khan SH, Aziz SA, Ul -Haq MI. 2011. Perforated peptic ulcers: A review of 36 cases.Professional Med J. 18: 124 -127.
45. Lee CW, Yip AW, Lam KH. 1993. Pneumogastrogram in the diagnosis of perforated peptic ulcer. Aust N Z J Surg. 63: 459 -461. Ref.: https://bit.ly/2TdVUR
46. Chen SC, Yen ZS, Wang HP, et al. 2002.Ultrasonography is superior to plain radiography in the diagnosis of pneumoperitonium. Br J Surg. 89: 351-354. Ref.: https://bit.ly/2UHzVXI
47. Mock CN, Amaral J, Visser LE. 1992. Improvement in survival from typhoid perforation. Ann Surg. 215: 244-249. Ref.: https://bit.ly/22GpGQt
48. Atoyebi OA, Adesanya AA, Atimomo CE, et al. 1999. Prognostic factors of typhoid perforation in Lagos. Nigerian Quarterly Journal of Hospital Medicine. 9:78-83. Ref.: https://bit.ly/2UGphk7
49. Ajao OG, Ajao A, Johnson T. 1984. Methylprednisolone sodium succinate (Solu -medrol) in the treatment of typhoid perforation. (a preliminary report). Trans R Soc Trop Med Hyg. 78: 573-576.
50. Adesunkanmi ARK, Ajao OG. 1996. Typhoid ileal perforation: the value of delayed primary closure of abdominal wounds. Afr J Med Sci Surg. 25: 311-315. Ref.: https://bit.ly/2W6WGog
51. Akalin NE. 1999. Quinolones in the treatment of typhoid fever. Drugs. 58: 52-54. Ref.: https://bit.ly/2Jkjori
52. Ranju C, Pais P, Ravindran GD et al. 1998. Changing pattern of antibiotic sensitivity of salmonella typhi. National Medical Journal of India. 11: 266-267. Ref.: https://bit.ly/2W6W9m6
53. Walter JB, Israel MS. 1979. General Pathology. Churchill Livingstone, Edinburgh. 92-102.
54. Crump JA, Ram PK, Gupta SK, et al. 2008. Part I Analysis of data gaps Salmonella enteric serotype Typhi infection in low and medium human development index countries, 1984 - 2005. Epidemiol Infect. 136: 436-448.
55. Ekenze SO, Okoro PE, Amah CC, et al. 2008. Typhoid ileal perforation: Analysis of morbidity and mortality in 89 children. Niger J Clin Pract. 11: 58-62. Ref.: https://bit.ly/2CnrFVO
56. Chalya PL, Mabula JB, Koy M, et al. 2012. Typhoid intestinal perforations at a University teaching hospital in Northwestern Tanzania: a surgical experience of 104 cases in a resource - limited setting. World J Emerg Surg. 7:4. Ref.: https://bit.ly/2Cq41GS
57. Tade AO, Olatuje SO, Osinpebi OA, et al. 2011. Typhoid Intestinal Perforations in a Tropical Tertiary Health Facility: A Prospective Study. East Cent Afr J Surg. 16: 72. Ref.: https://bit.ly/2HrqOY5
58. Ameh EA. 1999. Typhoid ileal perforation in children: A scourge in developing countries. Ann Trop Paediatr. 19: 267-272. Ref.: https://bit.ly/2FjgoYv
59. Uba AF, Chirdan LB, Ituen AM, et al. 2007. Typhoid intestinal perforation in children: A continuing scourge in a developing country. Pediatr Surg Int. 23: 33-39. Ref.: https://bit.ly/2TOF7gd
60. Rahman GA, Abubakar AM, Johnson AW, et al. 2001. Typhoid ileal perforation in Nigerian children: An analysis of 106 operative cases. 17: 628-630. Ref.: https://bit.ly/2TfHkK89
61. Perera N, Geary C, Wiselka M, et al. 2007. Mixed Salmonella infection: case report and review of the literature. 14: 134-135. Ref.: https://bit.ly/2UIedme
62. Agbakwuru EA, Adesunkanmi AR, Fadioro SO, et al. 2003. A review of typhoid perforation in rural African hospital. 22: 22-25. Ref.: https://bit.ly/2UFziOo
63. Ugwu BT, Yiltok SJ, Kidmas AT, et al. 2005. Typhoid intestinal perforation in North Central Nigeria. 24: 1-6. Ref.: https://bit.ly/2OiWU9j
64. Edino ST, Mohammed AZ, Uba AF, et al. 2004. Typhoid enteric perforation in North Western Nigeria. 13: 345-349. Ref.: https://bit.ly/2UFL773
65. Koume J, Kouadio L, Turquin HT. 2004. Typhoid ileal perforation: surgical experience of 64 cases. 104: 445-447. Ref.: https://bit.ly/2Y1MX4h
66. Van Basten JP, Stockenbrugger R. 1994. Typhoid perforation: A review of literature since 1960. 46: 336-339. Ref.: https://bit.ly/2TTSHe9
67. Ugochukwu AI, Amub OC, Nzegwu MA. 2013. Ileal perforation due to typhoid fever –review of operative management and outcome in an urban centre in Nigeria. 11: 218-222. Ref.: https://bit.ly/2UHCYPE
68. Gupta V, Gupta SK, Shuklal VK, Gupta S. 1994. Perforated typhoid enteritis in children. 70: 19-22. Ref.: https://bit.ly/2W4soCW
69. Anyanwu LJ, Mohammed A, Abdullahi L, et al. 2018. Determinants of postoperative morbidity and mortality in children managed for typhoid intestinal perforation in Kano Nigeria. Ref.: https://bit.ly/2JIRdfIP
70. Kayabali I, Gokcora MI, Kayabali M. 1990. Contemporary evaluation of enteric perforation in typhoid fever:
analysis of 257 cases. 75: 96-100. Ref.: https://bit.ly/2WaWfcF
71. Saxe JM, Cropsey R. 2005. Is operative management effective in treatment of perforated typhoid? 189: 342-344. Ref.: https://bit.ly/2O8D7ZQ
72. Adeniran JO, Taiwo JO, Abdur-Rahman LO. 2005. Salmonella intestinal perforation: (27 perforations in one patient, 14 perforations in another). Are the goal posts changing? J Indian Assoc Pediatr Surg. Ref.: https://bit.ly/2W1rOp4
73. Sumer A, Kemik O, Dulger AC, et al. 2010. Outcome of surgical treatment of intestinal perforation in typhoid fever. World J Gastroenterol. 16: 4164-4168. Ref.: https://bit.ly/2TZAwXO
74. Buttler J, Knight J, Nath SK, et al. 1985. Typhoid fever complicated by intestinal perforation: a persisting fatal Outcome requiring surgical management. 7: 244-256. Ref.: https://bit.ly/2Te6hb8
75. Adeloye A. 1987. Typhoid fever. In: Adeloye A(ed). Davey’s companion to surgery in Africa. Churchill Livingstone, Edinburgh. 309-316. Ref.: https://bit.ly/2Te6hb8
76. Dindo D, Demartines N, Clavien PA. 2004. Classification of Surgical Complications: A New Proposal with Evaluation in a Cohort of 6336 Patients and Results of a Survey. Ann Surg. 240: 205-213. Ref.: https://bit.ly/2W6xpDJ