Tanzania Journal of Health Research https://dx.doi.org/10.4314/thrb.v24i1.5
Volume 24, Number 1, January 2023

Diagnostic value of pneumoperitoneum on plain abdominal film in patients with suspected visceral perforation at Bugando Medical Centre, Mwanza, Tanzania

Johnson N. Mrema[1], Godfrey Kasanga[2], Phillipo L. Chalya[1]*, Fabian Massaga[1], Leonard Washington[1], William Mahalu[3]

[1]*Department of Surgery, Catholic University of Health and Allied Sciences-Bugando, Mwanza, Tanzania*
[2]*Department of Radiology, Catholic University of Health and Allied Sciences-Bugando, Mwanza, Tanzania*
[3]*Department of Cardiothoracic Surgery, Catholic University of Health and Allied Sciences-Bugando, Mwanza, Tanzania*

Abstract

Background: The presence of pneumoperitoneum on plain abdominal film has been widely used in many centres in Tanzania as primary diagnostic imaging in patients with suspected visceral perforation. However, its diagnostic value has not yet been assessed in any hospital in the country including Bugando Medical Centre (BMC), and therefore its use as a diagnostic tool in these patients is not justified. This existing knowledge gap prompted the author to conduct this study. The study aimed to determine the diagnostic value of pneumoperitoneum on plain abdominal film in patients with suspected visceral perforation in our local setting.

Methods: This was a prospective cross-sectional study among patients with suspected visceral perforation at BMC from June 2017 to May 2018. Pneumoperitoneum on plain abdominal radiography was evaluated, and the findings were cross-tabulated against operative findings, the gold standard. Then, the sensitivity, specificity, accuracy, Positive Predictive Value, Negative Predictive Value and accuracy were calculated to determine the diagnostic value of pneumoperitoneum on plain abdominal film. The Kappa statistic (κ) was calculated to determine the degree of agreement with operative findings.

Results: A total of 132 patients were studied. The median age of patients was 35 years. The diagnostic accuracy of pneumoperitoneum on plain abdominal film in the detection of perforation was 90.9% with sensitivity, specificity, PPV and NPV of 90.1%, 92.7%, 96.5% and 80.9% respectively. There was good agreement with operative findings (κ = 0.86). The perforations of the ileum, gastric, duodenum, colon and appendix accounted for 36.3%, 22.0%, 19.8%, 11.0% and 11.0% of cases, respectively. The sensitivity, specificity, PPV, NPV and accuracy perforations of the ileum, gastric, duodenum, colon and appendix were 61.5-100%, 31.7-46.5%, 10.6-37.7%, 85.1-100% and 38.6-59.1% respectively. The kappa statistics showed good agreement with the operative findings (ķ = 0.76-0.89).

Conclusion: The presence of pneumoperitoneum on plain abdominal film provides high diagnostic value in the detection of visceral perforation and can be employed at BMC to improve the diagnostic value in patients with suspected visceral perforation and subsequently reduce negative laparotomy and complication rates.

Keys: pneumoperitoneum, diagnostic value, plain abdominal film, visceral perforation, Tanzania

***Correspondence:** plchalya65@gmail.com

https://dx.doi.org/10.4314/thrb.v24i1.5

Background

Gastrointestinal tract perforation leading to secondary peritonitis is one of the common causes of surgical acute abdomen worldwide (Levison & Bush., 2000; Malangoni & Inui., 2006). Perforation of the GI tract can result from different causes: spontaneous, traumatic, or iatrogenic causes and has variable clinical presentations, particularly in the early clinical course (Simmen & Heinzelmann., 1996; Chakrabarti *et al*., 2014). GI tract perforation is the most common surgical emergency all over the world and is associated with significant morbidity and mortality (Malangoni & Inui., 2006; Chakrabarti *et al.,* 2014). Early recognition and prompt surgical treatment of GI tract perforation are of paramount importance if morbidity and mortality associated with GI tract perforation are to be avoided (Levison & Bush., 2000; Chakrabarti et al., 2014). Globally, up to 40% of hospital admissions for emergency surgery are caused by acute abdominal pain, a significant percentage of which result from GI tract perforation (Wittmann *et al.*, 1996; Ordoñez & Puyana, 2006; Schietroma *et al*., 2007; Chakrabarti *et al.,* 2014). In Tanzania, GI tract perforation continues to be one of the leading causes of morbidity and mortality and at BMC, it is the single commonest indication for admission reported in the surgical wards (Chalya *et al*.,2011; Chalya *et al.,* 2012; Mabula *et al*., 2012; Mabewa *et al.,* 2015).

The diagnosis of GI tract perforation is generally based on the identification of pneumoperitoneum in various abdominal imaging studies (Stapakis & Thickman, 1992; Van Ruler *et al.,* 2007; Langell & Mulvihill, 2008). The imaging modality should be fast, non-invasive, easily available, accurate and cost-effective in diagnosing peritonitis (Stapakis & Thickman, 1992). Plain abdominal radiography has been the first modality of choice in patients with suspected GI tract perforation. The hallmark of GI perforation on plain abdominal films is the presence of pneumoperitoneum (Stapakis & Thickman, 1992; Langell & Mulvihill, 2008). Recently, modern imaging modalities have been introduced in the diagnostic assessment of pneumoperitoneum and be more sensitive than abdominal radiographs for the detection of pneumoperitoneum (Van Ruler *et al.*, 2007; Iacobellis *et al.,* 2015). The success rate is between 83 and 100 per cent (Shukla *et al.,* 2015); However, most of this diagnostic imaging is expensive and commonly not available in many centres in a resource-limited setting. Thus, the plain abdominal film remains the first imaging study and gold standard diagnostic test available in most centres in resource-limited countries (Hebba *et al*., 2014; Iacobellis *et al.,* 2015).

Plain abdominal radiography has been shown by previous studies to be an easy, simple and cheap diagnostic tool for supporting the diagnosis of visceral perforation (Roh *et al.*, 1983; Stapakis & Thickman, 1992). However, its application and usefulness in the diagnosis of visceral perforation have not been evaluated at BMC; as a result, the rate of negative or delayed laparotomy resulting from misdiagnosis is not known. This existing knowledge gap prompted the author to conduct this study in our centre. The study is intended to evaluate the diagnostic utility of pneumoperitoneum on plain abdominal film in patients with suspected visceral perforation and to assess whether it can be employed as an alternative diagnostic tool in these patients at BMC. Findings from this study can help to assess whether pneumoperitoneum on plain abdominal film can be used at BMC to improve diagnostic accuracy in patients with suspected visceral perforation and subsequently reduce negative laparotomy and complication rates.

Patients and Methods

Study design and setting

This was a prospective cross-sectional study to determine the diagnostic value of pneumoperitoneum on plain abdominal film in patients with suspected visceral perforation at BMC over twelve months from June 2017 to May 2018.

https://dx.doi.org/10.4314/thrb.v24i1.5

The study was conducted in the emergency department and surgical wards of BMC. BMC is the only tertiary health institution serving the whole of the north-western part of Tanzania, serving a population of about 16 million. It is a 960-bed tertiary care hospital located in Mwanza City in north-western Tanzania on the southern border of Lake Victoria. It is also a teaching hospital for the Catholic University of Health and Allied Sciences—Bugando. The hospital provides both outpatient and inpatient surgical services, in addition to medical, paediatric and other health services. The hospital has a department of Radiology where several radiological services including plain x-rays, ultrasound, breast imaging, contrast studies, and CT scans are performed. There are no interventional radiological services at the moment probably due to a lack of this facility and expertise. The hospital has one main theatre which has ten rooms. These rooms are used for general surgery, orthopaedic surgery, otorhinolaryngology, obstetrics and gynaecology, urology, cardiothoracic and neurosurgery operations. The main theatre operates from Monday to Sunday, and every day all rooms are occupied with elective surgeries. Two rooms are located in the emergency department and are reserved for emergency cases. BMC was conveniently selected because being a tertiary care and Zonal hospital the majority of emergency surgical patients including those with perforated visceral

Study population, sample size estimation and sampling procedure

The study included all patients who underwent plain abdominal radiography for suspected visceral perforation and subsequently undergo laparotomy at BMC during the period of study. Patients who died before surgical treatment and those who had undergone laparotomy in the previous 30 days period were excluded from the study. The sample size was calculated by using Buderer's formula(Zaidi et al, 2016).

$$n = \frac{Z^2(1-\alpha/2) \times SN \times (1-SN)}{L^2 \times P}$$

Where n = required sample size, S_N = anticipated sensitivity, α = size of the critical region ($1 - \alpha$ is the confidence level), $z_{1-\alpha/2}$ = standard normal deviate corresponding to the specified size of the critical region (α), and L = absolute precision desired on either side (half-width of the confidence interval) of sensitivity or specificity.

P= Prevalence (55%)(Afridi et al, 2008)

$$n = \frac{1.96^2 \times 0.95 \times (1-0.95)}{0.05^2 \times 0.55} = 132$$

The minimum sample size was 132 patients. Convenience sampling of patients who met the inclusion criteria was performed until the sample size was reached.

Recruitment of patients and data collection

Recruitment of patients to participate in the study was done in the emergency department, surgical wards, and clinics of Bugando Medical Centre. All patients presented with suspected visceral perforation were screened for inclusion in the study. Patients who met the inclusion criteria were consecutively enrolled in the study after informed written consent was sought from the patients, parents or guardians. All patients included in the study were referred to the Department of Radiology for plain abdominal film examination. The diagnosis of visceral perforation was made from history, plain abdominal and chest radiographs, and confirmed at laparotomy. Information obtained from this study was entered in the pre-tested questionnaire designed for the study and included; demographic data, clinical and plain abdominal film findings, and intra-operative findings of patients.

https://dx.doi.org/10.4314/thrb.v24i1.5

Statistical data analysis

Data were entered into Microsoft excel and analyzed STATA version 13.0 (Collage Station, Texas, US). The median (+IQR) and ranges were calculated for continuous variables, whereas proportions, frequent tables, bars and pie charts were used for categorical variables. Study variables were presented as mean ± standard deviation for variables with normal distribution, and as median and interquartile range (IQR) for variables with skewed distributions. Pneumoperitoneum on plain abdominal radiography was evaluated, and the findings were cross-tabulated against operative findings, the gold standard. Then, 2 by-2 tables were used to calculate the sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and accuracy of pneumoperitoneum on plain abdominal film on diagnosing visceral perforation among patients with suspected visceral perforation. The level of significance was considered as $p< 0.05$. The Kappa statistic (κ) was calculated to determine the degree of agreement with operative findings. A value above 0.75 suggests excellent agreement with the gold standard (i.e. operative findings), 0.40 to 0.75 is intermediate to good agreement and below 0.40 suggests poor agreement.

Ethical clearance

Ethical approval and clearance to conduct this study were sought from the Department of Surgery and CUHAS/BMC research ethical committee with a research clearance certificate number CREC/265/2017. Permission to conduct the study was sought from the hospital authority. The protocol and importance of the study were explained to patients before recruitment into the study, followed by a signed written informed consent. Participants below 18 years old obtained ascent from their parents/guardians. All information regarding the patient will remain confidential. Patient records will be kept such that the identity of the patient will not be disclosed, and will be available only for review. The patient's refusal to consent or withdraw from the study did not alter or jeopardized their access to medical care. No conflicts of interest in the study.

Results

Socio-demographic and clinical characteristics of patients

During the period of study, a total of 132 patients suspected of visceral perforation were enrolled on the study. Their age ranged from 2 months to 83 years with a median age of 35 [IQR 21.5 – 48.5] years. The modal age group was 21-40 years accounting for (40.2%) of patients. The majority, 89 (67.4%) were males with a male-to-female ratio of 2.1: 1. These patients underwent plain abdominal X-ray and thereafter underwent explorative laparotomy for the diagnosis of perforated hollow viscera at Bugando Medical Centre. Table 1 summarizes the socio-demographic and clinical characteristics of patients enrolled on the study.

 https://dx.doi.org/10.4314/thrb.v24i1.5

Table 1: Socio-demographic and clinical characteristics of 132 patients

Patient Characteristics	Number (n)	Per cent (%)
Age group		
<20 years	25	18.9
21– 40	53	40.2
41– 60	41	31.1
>61	13	9.9
Sex		
Male	89	67.4
Female	43	32.6
Abdominal distension		
Yes	102	77.3
No	30	22.7
Vomiting		
Yes	107	81.1
No	25	18.9
Constipation		
Yes	56	42.4
No	76	57.6
Fever		
Yes	73	55.3
No	59	44.7
Abdominal pain		
Yes	115	87.1
No	17	12.9

Abdominal X-ray and Laparotomy findings

Of the 132 patients suspected of peritonitis, 85 (64.4%) had pneumoperitoneum on plain abdominal x-ray whereas, upon laparotomy, 91 (68.9%) had perforations on various sites. Table 2 below summarizes the findings of pneumoperitoneum and operative findings. Of the 91 patients who had perforations on laparotomy, the perforated hollow viscus was found at ileum 36.3% (33/91), gastric 22.0% (21/91), colon 19.8% (18/91), duodenum 11.0% (10/91) and appendix 11.0% (10/91) as shown in Figure 1.

Table 2: Findings of pneumoperitoneum and perforation on laparotomy

Findings	Number (n)	Per cent (%)
Pneumoperitoneum		
Yes	85	64.4
No	47	35.6
Perforation on laparotomy		
Yes	91	68.9
No	41	31.1

https://dx.doi.org/10.4314/thrb.v24i1.5

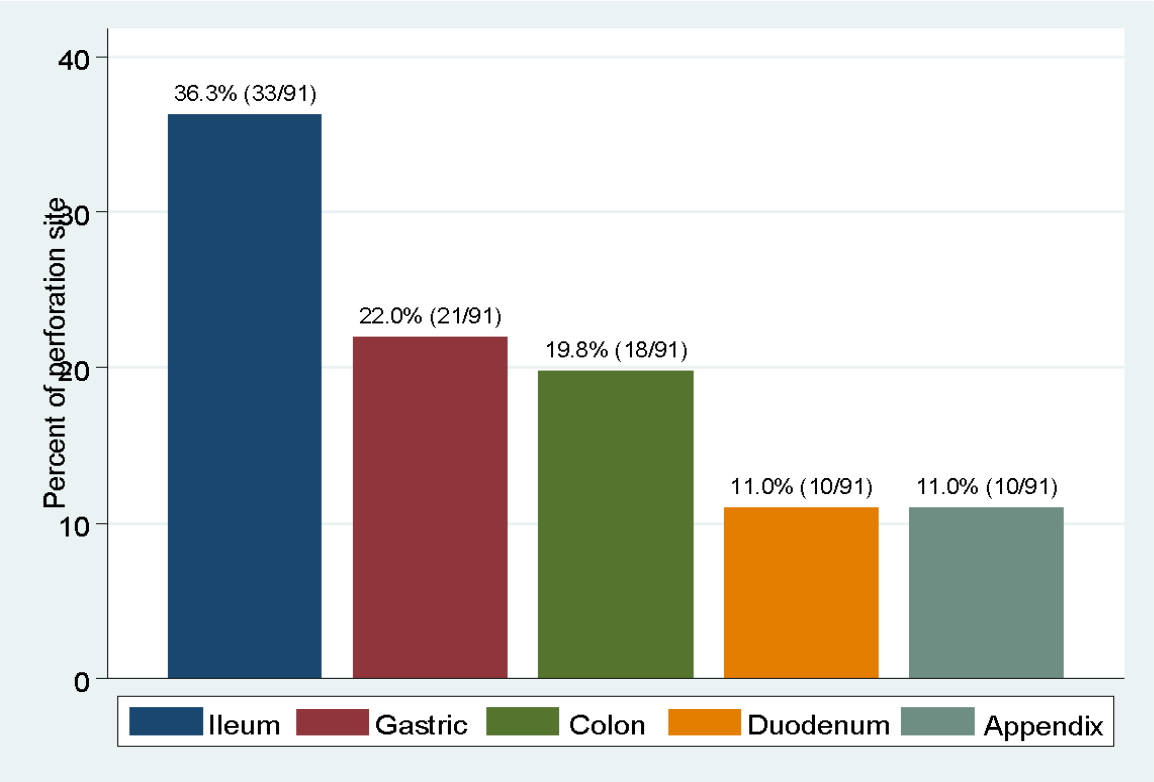

Figure 1 Number and sites of perforations among 91 patients

Diagnostic value of pneumoperitoneum on plain abdominal film in patients suspected of visceral perforation

The Sensitivity and specificity of pneumoperitoneum on plain abdominal film in the detection of perforation was 90.1% (82/91) [95% CI 81.9% – 94.8%] and 92.7% [95% CI 78.8% – 97.7%] (38/41) respectively. The positive predictive value and negative predictive value of pneumoperitoneum on plain abdominal film in the detection of perforation were 96.5% [95% CI 89.4% - 98.9%] (82/85) and 80.9% [95% CI 66.5% – 90.0%] (38/47) respectively. The accuracy of pneumoperitoneum on plain abdominal film in the detection of perforation was 90.9% [95% CI 84.6% – 94.8%] (120/132). The kappa statistic (κ) showed excellent agreement with the operative findings, the gold standard (κ=0.86). Table 3 below summarizes the diagnostic value (sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and accuracy) of pneumoperitoneum on plain abdominal film.

 https://dx.doi.org/10.4314/thrb.v24i1.5

Table 3: Diagnostic value of pneumoperitoneum on plain abdominal film

Pneumoperitoneum on plain abdominal X-ray	Perforation on Laparotomy		Total
	Yes	No	
Yes	82	3	85
No	9	38	47
Total	91	41	132

Table 4: Diagnostic value of Pneumoperitoneum on Plain Abdominal film on Ileum, Gastric, Duodenum, Colon, and Appendix perforations

Pneumoperitoneum on plain abdominal X-ray	Yes	No	Total	SN	SP	PPV	NPV	ACC	κ
Perforation on Ileum									
Yes	32	53	85	97.0	46.5	37.7	97.9	59.1	0.78
No	1	46	47						
Total	33	99	132						
Perforation on Gastric									
Yes	21	64	85	100	42.3	24.7	100	51.5	0.89
No	0	47	47						
Total	21	111	132						
Perforation on Duodenum									
Yes	21	64	85	100	42.3	24.7	100	43.2	0.76
No	0	47	47						
Total	21	111	132						
Perforation on Colon									
Yes	11	74	85	61.5	35.1	12.9	85.1	38.6	0.79
No	7	40	47						
Total	18	114	132						
Perforation on Appendix									
Yes	9	76	85	90.0	37.7	10.6	97.9	41.7	0.77
No	1	46	47						
Total	10	122	132						

Keys: SN = Sensitivity, SP = Specificity, PPV= Positive Predictive Value, NPV = Negative Predictive Value, ACC= Accuracy, κ =Kappa statistics

Discussion

Globally, peritonitis resulting from hollow visceral perforation is one of the common surgical emergencies (Malangoni & Inui., 2006; Langell & Mulvihill, 2008; Chakrabarti *et al.,* 2014). The plain abdominal film has traditionally been used as primary diagnostic imaging for patients suspected of visceral perforation. This may be explained by its relative accessibility, affordability and safety as compared to other sophisticated imaging such as abdominal ultrasound and computerized tomography scan (Grassi *et al*., 2004; Langell & Mulvihill, 2008; Shukla *et al.,* 2015). In this study, the highest incidence of visceral perforation occurred in the third and fourth decades of life which is in keeping with other studies (Langell & Mulvihill, 2008; Chalya *et al.,* 2012). We could not find the reasons for the high incidence of visceral perforation in this

https://dx.doi.org/10.4314/thrb.v24i1.5

age group in our setting. As reported by other authors (Langell & Mulvihill, 2008; Hebbar *et al.,* 2014), peritonitis resulting from the visceral perforation in the current study was more common in males than in females. The exact reason for this male preponderance is not known although men may have an increased risk for perforation.

Clinical manifestations of visceral perforation depend somewhat on the organ affected and the nature of the contents released as well as the ability of the surrounding tissues to contain those contents (Grassi *et al*., 2004). The clinical presentation of visceral perforation in our patients is not different from those in other geographical areas (Langell & Mulvihill, 2008, Iacobellis *et al.*, 2015; Mabewa *et al*., 2015), with abdominal pain being common to all patients. Similar observations were made by Ghooi and Panjwani *et al* (1978) and Desa *et al* (1983) in their studies. Hollow visceral perforation may occur at any anatomical location from the upper oesophagus to the anorectal junction (Hebbar et al., 2014). In keeping with other studies (Chalya *et al.*,2011; Chalya *et al.,* 2012), the ileum was the commonest site of perforation in the present study. This observation is contrary to what was reported in the same hospital four years ago by Mabewa *et al.* (2015) which showed the appendix as the most common site of perforation. In India reported that the commonest site of perforation was the gastro-duodenal region (Chourashiya *et al.,* 2017). However, in our study, the reasons for the observed anatomical distribution could not be established.

The diagnosis of hollow organ perforation is usually based on the presence of free intraperitoneal air on the chest or abdominal radiography (Braccini et al., 1996; Grassi et al., 2004). In agreement with other studies (Langell & Mulvihill, 2008; Shukla et al., 2015), the diagnosis of visceral perforations in this study was made clinically and through identification of free air under the diaphragm in plain abdominal and chest radiographs, and the diagnosis was confirmed at laparotomy. Plain radiography has been the first modality of choice for patients with suspected GI tract perforations (Grassi et al., 2004; Langell & Mulvihill, 2008; Shukla et al., 2015). Recently, computerized tomography scans with oral contrast are now considered the reliable method of detecting small pneumoperitoneum before surgery and the gold standard for the diagnosis of perforation. Abdominal Ultrasonography has also been found to be superior to plain radiographs in the diagnosis of free intra-peritoneal air (Hebbar et al., 2014). None of these imaging studies was used in the diagnosis of free intra-peritoneal air in our study. We relied on plain radiographs of the abdominal/chest to establish the diagnosis of free intraperitoneal air which was demonstrated in 64.4% of cases, a figure which is lower than the 74.7% that was reported previously at the same centre by Chalya *et al* (2012). In the studies conducted by Dandy *et al* (1919) and Afridi *et al* (2008); the air under the diaphragm on plain abdominal X-ray was seen in 75% and 70% respectively. We could not establish, in our study, the reasons for the low detection rate of free air under the diaphragm.

In this study, the diagnostic accuracy of pneumoperitoneum on plain abdominal film in the detection of perforation was 90.9% with sensitivity, specificity, PPV and NPV of 90.1%, 92.7%, 96.5% and 80.9% respectively. There was good agreement with operative findings (κ = 0.86). These findings are comparable with the findings of other studies (Braccini et al., 1996; Romero *et al*., 2002; Van Randen *et al*., 2011). The high diagnostic accuracy of pneumoperitoneum on plain abdominal film in the detection of perforation in the present study can be attributed to the fact that the majority of patients presented late with advanced disease and therefore the diagnosis of viscus perforation was straightforward. The diagnostic value of pneumoperitoneum on plain abdominal film in the detection of perforation may further be improved by the use of abdominal Ultrasonography or CT scans.

The diagnostic value of pneumoperitoneum on plain abdominal film in

https://dx.doi.org/10.4314/thrb.v24i1.5

the detection of viscus perforation has been reported to differ according to the anatomical site of perforation (Langell & Mulvihill, 2008). In the present study, perforations of the ileum, gastric, duodenum, colon and appendix accounted for 36.3%, 22.0%, 19.8%, 11.0% and 11.0% of cases, respectively. The sensitivity, specificity, PPV, NPV and accuracy were 61.5-100%, 31.7-46.5% 10.6-37.7%, 85.1-100% and 38.6-59.1% respectively. The kappa statistic shows good agreement with the operative findings (ķ = 0.76-0.89). This observation concurs with findings from other studies (Karahan *et al*., 2004; Hebbar *et al*., 2014). In our study, the diagnostic value of pneumoperitoneum on plain abdominal film in the detection of specific visceral perforations was low compared to figures reported in developed countries (Grassi *et al*., 2004). The difference in our evaluation of abdominal plain film by the routine use of the cross-table lateral radiograph of the abdomen in the supine or left lateral decubitus positions, a supine projection, and a chest radiograph may explain these differences. Because pneumoperitoneum may indicate a life-threatening situation, radiologists need to be aware of these different projections and their relative value in diagnosing this condition. The diagnostic value of pneumoperitoneum on plain abdominal film in the detection of specific visceral perforations may further be improved by the use of abdominal Ultrasonography or CT scans in cases when plain abdominal radiography showed equivocal findings.

In conclusion, this study has shown that the presence of pneumoperitoneum on plain abdominal film is an accurate, simple and cheap diagnostic tool and provides high diagnostic value in the detection of visceral perforation at Bugando Medical Centre. Therefore, pneumoperitoneum on plain abdominal film should be used at Bugando Medical Centre to improve the diagnostic value in patients with suspected visceral perforation and reduce negative laparotomy and complication rates. Also, similar studies involving large sample sizes should be conducted at Bugando Medical Centre to assess the diagnostic value of plain abdominal film in the detection of pneumoperitoneum in suspected cases of hollow visceral perforation.

Acknowledgements

The authors thank all those who participated in the preparation of this manuscript and those who were involved in the care of our patients. Special thanks go to senior house officers in the department of surgery for their support in data collection.

References

Afridi, S.P., Malik, F., Ur-Rahman, S., Shamim, S., Samo, K.A. (2008) Spectrum of perforation peritonitis in Pakistan: 300 cases Eastern experience. *World Journal of Emergency Surgery* 3, 31

Braccini, G., Lamacchia, M., Boraschi, P., Bertellotti, L., Marrucci, A., Goletti, O., Perri, G. (1996) Ultrasound versus plain film in the detection of pneumoperitoneum. *Abdominal Imaging* 21, 404–12.

Chalya, P.L., Mabula, J.B., Koy, M., Mchembe, M.D., Jaka, H.M., Kabangila, R., Chandika, A.B., Gilyoma, J.M. (2011) Clinical profile and outcome of surgical treatment of perforated peptic ulcers in Northwestern Tanzania: A tertiary hospital experience. *World Journal of Emergency Surgery* 6:31.

Chalya, P.L., Mabula, J.B., Koy, M., Kataraihya, J.B., Jaka, H., Mshana, S.E., Mirambo, M., Giiti, G., Gilyoma, J.M. (2012) Typhoid intestinal perforations at a University teaching hospital in Northwestern Tanzania: A surgical experience of 104 cases in a resource-limited setting. *World Journal of Emergency Surgery* 7, 4.

Chakrabarti, S., Chakrabarti, P.R., Deolekar, S.R., Shah, J. (2014) Spectrum of perforative peritonitis in Navi Mumbai : Analysis of 100 cases. *Indian Journal* of *Basic and Applied Medical Research 3,* 122–9

https://dx.doi.org/10.4314/thrb.v24i1.5

Chourashiya, B.K., Porwal, S., Porwal, V., Gupta, A. (2017) A Clinical Study of the Spectrum of Gastrointestinal Perforation Peritonitis in Rural Southern East Rajasthan. *Journal of Universal Surgery*. 5, 2.

Dandy, W.E. (1919) Pneumoperitoneum: a method of detecting intestinal perforation—an aid in abdominal diagnosis. *Annals of Surgery* 70, 378.

Desa, L., Mehta, S., Nadkarni, K.B.R. (1983) Peritonitis: A study of factors contributing to mortality. *Indian Journal of Surgery* 45, 593.

Ghooi, A.M., Panjwani, S.P. (1978) Acute abdominal emergencies: Clinical overview. *Indian Journal of Surgery* 140, 182–9.

Grassi, R., Romano, S., Pinto, A., Romano, L. (2004) Gastro-duodenal perforations: Conventional plain film, US and CT findings in 166 consecutive patients. *European Journal of Radiology* 50, 30–6.

Hebbar, A., T.M. S., Iyanna, H., BV, S. (2014) Prospective study of comparison between the ultrasonography with the plain radiography in the diagnosis of pneumoperitoneum of hollow viscus perforation. *International Journal of Research in Medical Sciences* 2,154

Iacobellis, F., Berritto, D., Grassi, R. (2015) Diagnostic approach to alimentary tract perforations. *Imaging of Alimentary Tract Perforation*. 1–7

Langell, J.T., Mulvihill, S.J. (2008) Gastrointestinal Perforation and the Acute Abdomen. *Medical Clinics of North America* 92, 599–625.

Levison, M.E., Bush, L.M. (2000) Peritonitis and other intra-abdominal infections. In: Churchill Livingstone, editor. *Principles and practice of infectious diseases*. 5th ed. Philadelphia, 821–56.

Karahan, O.I., Kurt, A., Yikilmaz, A., Kahriman, G. (2004) New method for the detection of intraperitoneal free air by sonography: scissors maneuver. *Journal of Clinical Ultrasound* 32, 381-5.

Mabewa, A., Seni, J., Chalya, P.L., Mshana, S.E., Gilyoma, J.M. (2015) Etiology, treatment outcome and prognostic factors among patients with secondary peritonitis at Bugando Medical Centre, Mwanza, Tanzania. *World Journal of Emergency Surgery* 10, 47.

Mabula, J.B., Chalya, P.L., Mchembe, M.D., Kihunrwa, A., Massinde, A., Chandika, A.B., Gilyoma, J.M. (2012) Bowel perforation secondary to illegally induced abortion: a tertiary hospital experience in Tanzania. *World Journal of Emergency Surgery* 7, 29.

Malangoni, M.A., Inui, T. (2006) Peritonitis - The Western experience. *World Journal of Emergency Surgery* 1, 1–5.

Ordoñez, C.A., Puyana, J.C. (2006) Management of peritonitis in the critically ill patient. *Surgical Clinics of North America* 86, 1323–49.

Romero, J.A., Castaño, N., Chen, S.C. (2002) Ultrasonography is superior to plain radiography in the diagnosis of pneumoperitoneum. *British Journal of Surgery* 89, 1194–5.

Schietroma, M., Carlei, F., Cappelli, S., Pescosolido, A., Lygidakis, N. A.G. (2007) Effects of cholecystectomy (laparoscopic versus open) on PMN-elastase. *Hepato-gastroenterology* 54, 342–5.

Shukla, A., Bharti, R., Chaudhary, R., Sharma, M. (2015) Diagnostic value of Plain Abdominal Radiograph, Ultrasonography and Clinical impression of the surgeon in acute peritonitis. *Annals of International medical and Dental Research* 1, 66-71

Simmen, H., Heinzelmann, M.L.F. (1996) Peritonitis: Classification and causes. *Digestive Surgery* 13, 381–3.

Stapakis, J.C., Thickman, D. (1992) Diagnosis of pneumoperitoneum: Abdominal CT scan versus Upright chest film. *Journal of Computer Assisted Tomography* 16, 713–6.

Van Ruler, O., Mahler, C.W., Boer, K.R.,

Reuland, E.A., Gooszen, H.G., Opmeer, B.C., et al. (2007) Comparison of on-demand versus planned relaparotomy strategy in patients with severe peritonitis: A randomized trial. *Journal of the American Medical Association*. 865–873

Van Randen, A., Laméris, W., Luitse, J.S.K., Gorzeman, M., Hesselink, E.J., Dolmans D.E.J.G.J. (2011) The role of plain radiographs in patients with acute abdominal pain at the Emergency Department. *American Journal of Emergency Medicine* 29, 582–9.

Wittmann, D.H., Schein, M., Condon, R.E. (1996) Management of secondary peritonitis. *Annals Surgery* 224, 10–8.

Zaidi, Waseem H, Fahim Ahmed Ansari M, Irfan M, Mustansir Hussain Zaidi S, Fatima Waseem H (2016) Sample Size Estimation Of Diagnostic Test Studies in Health Sciences. 14th International Conference on Statistical Sciences [Internet]. 29, 239–46. Available from: https://www.researchgate.net/publication/303897592.