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Original Research Article

COMPARATIVE STUDY OF ULTRASOUND ABDOMEN AND XRAY ABDOMEN IN DETERMINING NEED FOR SURGICAL INTERVENTION IN NEONATES WITH NECROTISING ENTEROCOLITIS

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Abstract

Background: Necrotizing enterocolitis (NEC) is one of the most common gastrointestinal conditions in premature neonates. Significant amount of mortality and morbidity is associated with NEC. Traditionally X-Ray abdomen has been used for routine follow-up and staging which exposed the neonates to radiation. Alternatively USG, if used for the same can solve this problem. The objectives are to study the diagnostic utility of Ultrasound Abdomen in detecting and predicting the need for surgical intervention in neonates with clinically diagnosed necrotising enterocolitis, admitted in new born unit of our institution and to compare it with the already established utility i.e. X-ray abdomen. **Materials and Methods:** This is a Descriptive study (Diagnostic test evaluation) done in 200 neonates admitted in the neonatal unit of our institution diagnosed with NEC. **Result:** The study was conducted in 200 patients in which majority were found to be males, most common age group was 4 to 6 days, weight between 1.6 and 2 kg and in late preterm category. Most of the patients were having stage 1A and 1B NEC. 34 patients had Stage 3 NEC, of which 32 patients were operated and findings of NEC were confirmed. The most common site involved was large bowel, seen exclusively in term babies. The radiological findings of ascites, pneumoperitoneum, focal fluid collection and bowel wall thinning were exclusive to stage 3 NEC. The diagnostic utility of USG abdomen and X-ray abdomen in assessing these findings was compared. Ultrasound was found to be more sensitive than X-ray with a specificity of 86.9% and sensitivity of 93.8%. X-ray had a specificity of 96.4% and sensitivity of 18.8%. **Conclusion:** After the comparative study of Ultrasound and X-ray abdomen in 200 patients for determining the need for surgical intervention in neonates with necrotizing enterocolitis, USG abdomen was found to be a more sensitive tool.

INTRODUCTION

Necrotizing enterocolitis (NEC) is an acquired inflammatory disease that affects the gut of new born infants nearly exclusively. Although first described as a disease of prematurity, 10 % of the patients are full-term infants. Despite decades of research, NEC remains a leading cause of infant morbidity and mortality in neonatal intensive care units (NICUs). Neurodevelopmental impairment occurs in the majority of survivors. Early diagnosis and adequate treatment are essential in the presence of clinical suspicion of NEC.

Plain abdominal radiography is currently the imaging modality of choice for evaluation of neonates with NEC and to decide the need for surgery. X-Ray may be performed as frequent as every 6 hours because of the rapid evolution that may occur in the patient's clinical condition. This results in significant X-ray exposure of these neonates.

However, in the recent years USG (ultrasound abdomen) is playing an increasing role in diagnosis

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and staging of NEC. It can assess in real time the presence of peristalsis of the bowel loops, detect the thickness of the intestinal wall and the presence of minimal amounts of fluid in the peritoneal cavity. Thinning of the bowel wall and lack of perfusion in sonography are highly suggestive of nonviable bowel. These changes may be seen before visualization of pneumoperitoneum on plain abdominal radiography. Once perforated, mortality rate is higher. So earlier detection of severely ischemic or necrotic bowel loops, before perforation occurs, could potentially improve the morbidity and mortality in NEC. So, abdominal sonography may be used for staging and also to decide upon the need for surgical intervention in NEC.

MATERIALS AND METHODS

Our primary objective was to study the diagnostic utility of Ultrasound Abdomen in detecting and predicting the need for surgical intervention in neonates with clinically diagnosed Necrotising Enterocolitis admitted in new born unit of our institution, during the period January 2018 to December 2022 and to compare it with the already established diagnostic investigation i.e. X-ray abdomen.

Our study was an ambispective descriptive study (diagnostic test evaluation) on full term and preterm neonates admitted with the diagnosis of NEC in our institution during the study period. Neonates diagnosed with NEC but treated surgically from some other centre and referred to our institution, neonates who underwent laparotomy for some other conditions and developed NEC in post-operative period and NEC patients in which USG and X-ray were not available were excluded from the study.

Minimum study sample required was 82, calculated using the formula $Z\alpha^2$ x sensitivity x (1-sensitivity)/ d 2. Sensitivity of USG was 82%, according to a study by Silva CT et al,[1] in 2007. Prevalence of Surgical NEC was taken according to a study by Jamie R Robertson in 2018.[2]

Data collection was started after Institutional Review Board approval (IRB number: 37/2022 dated 31 May 2022). In all cases from June 2022 to December 2022, informed consent was taken from the mother or father of all the full term and preterm newborns with NEC. In clinically suspected cases of NEC, routine blood examination, C-reactive protein and stool occult blood is done. Plain X-ray abdomen and bedside USG abdomen is taken and the disease is staged according to Modified Bells Criteria and DAAS score. [3,4] In cases before June 2022, Case Records of all the clinically diagnosed cases of NEC were reviewed. Plain X-ray abdomen and USG abdomen taken during the period were reviewed and the disease staged according to Modified Bells Criteria and DAAS score.

USG abdomen findings that were looked for included abnormal bowel wall echo pattern – loss of hypo-echoic muscle layer, bowel wall thickening (> 2.6 mm),[5] bowel wall thinning (< 1 mm),[5] the presence of intramural gas, portal pneumatosis, extra-intestinal gas, ascites and focal fluid collection.

USG findings were correlated with clinical and X-ray findings. In patients who were taken up for surgical intervention, USG and X-ray findings were correlated with the laparotomy findings.

RESULTS

A total of 200 patients were studied. Majority of the patients (38%, n=76) belonged to the age group 4 to 6 days. Least number of patients belonged to the age group 10-12 days i.e. 16 % (n=32). The majority ie 61% (n=122) belonged to the male gender. Most of the babies belonged to the weight range of 1.6 to 2 kg (40 %, n=80). 21% (n=42) had a weight less than 1.5 kg and only 17% (n= 34) had a weight more than 2.6 kg. 47% (n= 94) of the babies had a gestational age of 34 to 37 weeks. [Figure 1]

Formula feeding was the most frequent risk factor seen in the study population. 65% (n=130) had this risk factor. 48% (n=96) had history of perinatal asphyxia and 45% (n=90) had history of congenital heart disease.

51% of total cases (n=102) had stage 1 NEC [1A:52 patients (26% of total cases),1B:50 patients (25% of total cases)]. 32 % (n=64) and 17% (n=34) had Stage 2 [2A:38 patients (19%), 2B:26 patients (13%)] and Stage 3 NEC [3A: 26 patients (13%) , 3B:8 patients(4%)] respectively. [Figure 2].

100% (n=34) of Stage 3 NEC patients had severe abdominal tenderness and increasing abdominal tenderness. 82.35% (n=28) had abdominal wall erythema/cellulitis and features of peritonitis. Only 70.58% (n=24) had an abdominal mass on examination.

Out of the 200 subjects 168 babies were conservatively managed. 6 of these babies expired. 32 were surgically managed and all of them survived.

On laparotomy 56.3% (n=18) had exclusive large bowel involvement. 6.2% (n=2) had exclusive small bowel involvement. 37.5% (n=12) had both small and large bowel involvement. 75% (n=24) of the operated patients were above 37 weeks of gestational age, out of which 75% (n=18) had exclusive large bowel involvement. Rest of this group had combined large and small bowel involvement. 18.75% (n=6) of operated patients belonged to 34 to 37 weeks group and they had combined small and large bowel involvement. Rest of the operated patients (n=2) belonged to 32 to 34 weeks group and had exclusive small bowel involvement.

Bowel dilatation was detected by X-ray in 50% cases (n=26) in Stage 1A, 92% (n=46) in Stage 1B, 89.4% (n=34) in Stage 2A, 84.6% (n=22) in Stage 2B and 100% (n=26) in Stage 3A patients. X-ray

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didn't detect any case in Stage 3B. USG detected dilatation in 15% (n=8) of cases in Stage 1A, 40% (n=20) in Stage 1B, 78.9% (n=30) in Stage 2A, 69.2% (n=18) in Stage 2B, 100% (n=26) in Stage 3A and 25% (n=2) in Stage 3B.

Bowel wall thickening was identified by X-ray only in Stage 3B cases and in 25% (n=2) cases only. USG identified the finding in 7% (n=4) of Stage 1A, 40% (n=20) of Stage 1B 89.4% (n=34) of Stage 2A and in all cases of Stage 2B, 3A and 3B.

Pneumatosis intestinalis was identified by X-ray in 52.56 % (n=20) of cases of Stage 2A, 46.1% (n=12) cases of Stage 2B, 61.5% (n=16) in Stage 3A and 75% (n=6) in Stage 3B. USG detected 84.2% (n=32) cases in Stage 2A, 76.9% (n=20) in Stage 2B, 100% (n=26) in 3A and 75% (n=6) in Stage 3B. No cases where detected by Xray or USG in stage 1A or 1B. [Figure 3]

Portal venous gas was detected by X-ray in 30.7% (n=8) of cases in Stage 2B only. It didn't detect any cases in Stage 3A or 3B. USG identified the finding in 30.7% (n= 8) of cases in Stage 2B and in all cases of 3A and 3B. Neither X-ray nor USG could detect portal venous gas in Stage 1A,1B or 2A. [Figure 4]

X-ray failed to detect bowel wall thinning in all the cases.USG detected bowel wall thinning in 84.6 % (n= 22) of cases in Stage 3A and 100 % (n=8) of cases of Stage 3B also. [Figure 5]

Pneumoperitoneum was detected by X-ray in 100% (n=8) of cases in Stage 3B. Only 50% (n=4) of cases were detected by USG in Stage 3B. [Figure 6]

USG detected focal fluid collection in 69.2 % (n=18) of cases in Stage 3A and in 100% (n=8) in Stage 3B. No cases where detected by X-ray. [Figure 7]
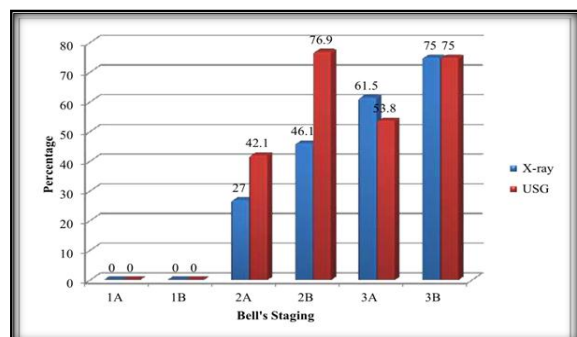
Table 1: Sensitivity and Specificity of USG

Result	Surgery not required	Surgery required	Total
Negative	142	2	148
Positive	22	30	52
Total	168	32	200

Table 2: Sensitivity and Specificity of X-ray

| Result	Surgery not required	Surgery required	Total
Negative	162	26	188
Positive	6	6	12
Total	168	32	200
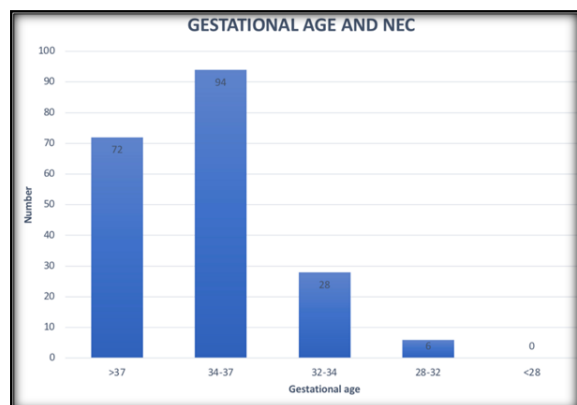
Figure 1: NEC and Gestational age

Figure 3: Pneumatosis Intestinalis- X-Ray vs USG

Ascites was detected by USG in 23% (n=6) of cases in Stage 3A and in 100% (n=8) of cases in Stage 3B. Ascites was not at all identified by X-ray. [Figure 8]

4 findings that were seen exclusively and statistically associated to stage 3 disease were bowel wall thinning, pneumoperitoneum, focal fluid collection and ascites. All the stage 3 cases except 2 were operated and NEC stage 3 confirmed.
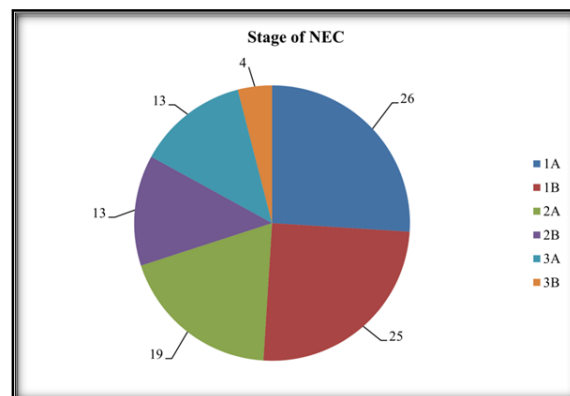

Figure 2: Stages of NEC
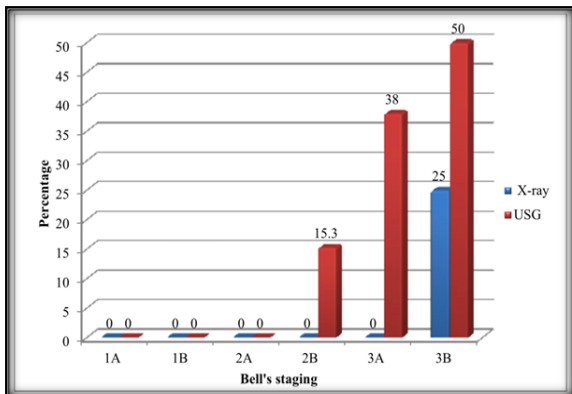
Figure 4: Portal venous gas- X-ray vs USG

Sensitivity and specificity of X-ray and USG in identifying these findings were calculated. Specificity and sensitivity of USG was 86.9% and 93.8% respectively and that of X-ray was found to be 96.4% and 18.8% respectively. [Table 1, 2]. In all these operated cases preoperative USG confirmed the presence of Stage 3 disease by demonstrating the above mentioned 4 classical radiological findings.

Receiver operated characteristic curves were drawn for USG and X-ray and area under the curves were calculated. Area under the curve of ROC for USG is 0.903. [Figure 9]. In case of X-Ray it is only 0.576. [Figure 10]
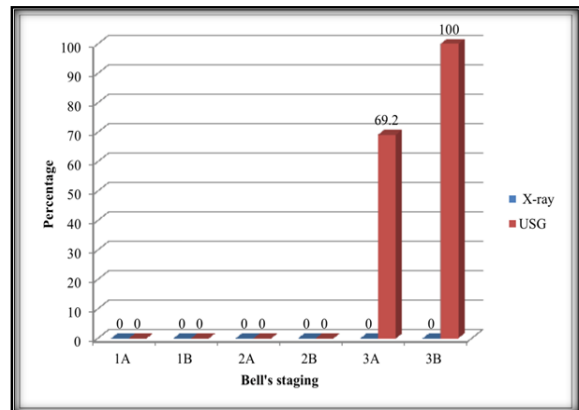
Hence for deciding whether a patient with NEC is to be operated or not, USG abdomen is a more sensitive test.
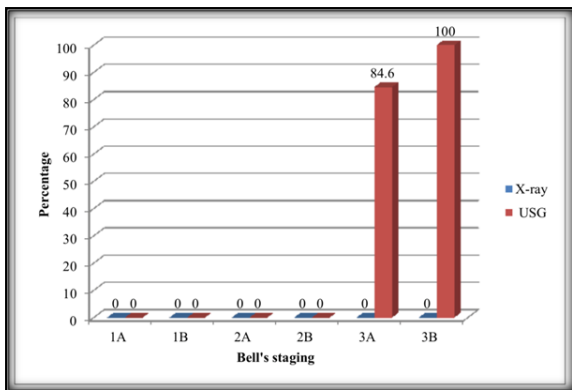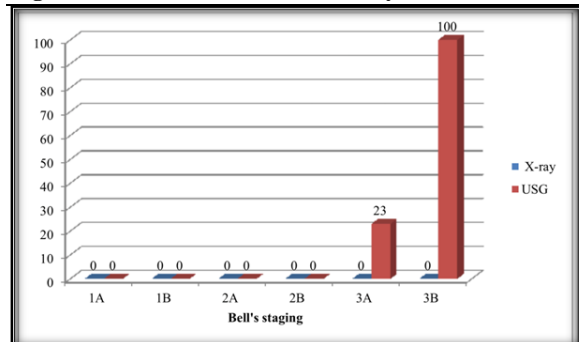

Figure 5: Bowel wall thinning- X-ray vs USG
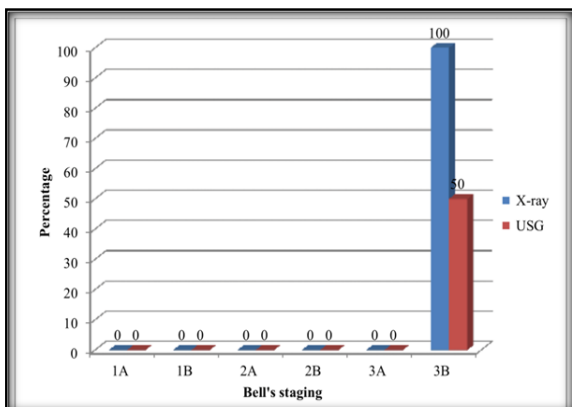
Figure 6: Pneumoperitoneum-X-ray vs USG

Figure 7: Focal fluid collection- X-ray vs USG

Figure 8: Ascites- X-ray vs USG
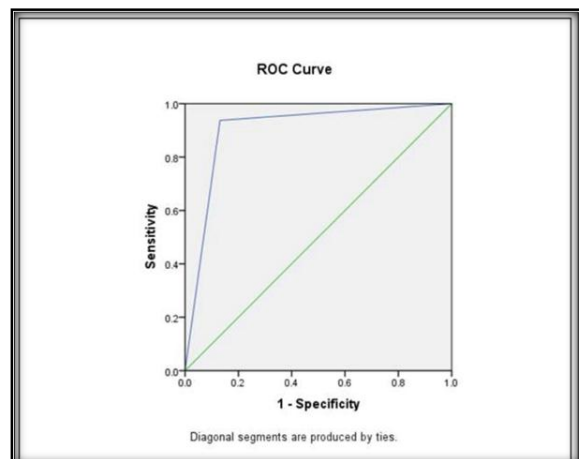
Figure 9: Receiver operating characteristic curve (ROC): USG

Area under the curve:0.903
P-value: 0.001

Figure 10: Receiver operating characteristic curve (ROC): X-ray

Area under the curve: 0.576

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DISCUSSION

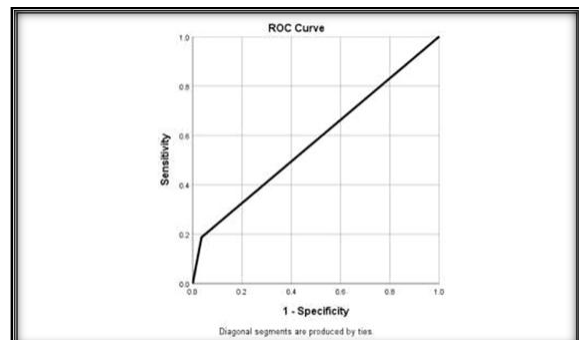This study was conducted at Government Medical College, Kottayam to study the sensitivity of USG abdomen and X-Ray abdomen in determining the need for surgical intervention in neonates with necrotising enterocolitis.

A total of 200 patients were studied. Majority of the patients (61%) were males. In a study by Carter BM et al [6] no relationship between gender and NEC was noted. But another study done by Adolfo R. Llanos et al [7] showed an increased frequency of occurrence in males.

Most of the subjects (40%) had their weight between 1.6-2.0 kg. Incidence decreased with increasing birth weight. The study by Adolfo R. Llanos et al [7] confirmed the finding. According to the study "the highest incidence of NEC occurred among infants weighing 750–1000g at birth and declined with increasing birthweight".

Most of the subjects belonged to the late preterm category i.e. 34- 37 weeks (47%). 36% were term infants. Neu J. et al,[8] states that necrotizing enterocolitis occurs primarily among prematurely delivered infants. But NEC can occur in term infants also. DK Lambert et al,[9] describes data from 2001 to 2006 regarding NEC in term infants. This study postulates that the combination of reduced mesenteric perfusion and feeding with artificial formula were factors predisposing them to develop NEC.[9]

The predominant risk factor in our study was formula feeds. 65% of our study population had the history of formula feeds even though not exclusive. Lucas A et al,[10] found that in exclusively formula-fed babies, confirmed disease was 6-10 times more common than in those fed breast milk alone and 3 times more common than in those who received formula plus breast milk.[10]

In our study the prevalence of different stages of NEC i.e. 1A,1B,2A,2B,3A and 3B are 26, 25, 19, 13, 13 and 4 percentage respectively. A similar prevalence of various stages of NEC was reported in various studies including studies by Prithviraj et al [11] and Katherine E. Gregery et al.[12]

In this study there were 34 subjects who belonged to Category 3 NEC. 75% of the group which required surgery were term babies. Findings like hypotension, bradycardia, episodes of apnoea, acidosis and severe thrombocytopenia were present in all the patients. All the patients had severe abdominal tenderness and increasing distension on examination. Abdominal wall erythema /cellulitis and peritonitis was seen in 82.5% of patients. A definite abdominal mass was palpable in 70.5% of subjects. In the study by Prithviraj et al 100% of patients who required surgery had abdominal distension and tenderness. Abdominal cellulitis was there in 66% of patients. Acidosis, thrombocytopenia and neutropenia were there in all those patients who required surgery.

In our study 75% of patients who ultimately required surgery were term babies. In all these cases large bowel involvement was there. Majority of the cases were having focal NEC also. The literature regarding surgical findings and its relationship to clinical outcomes is sparse. Fasoli et al,[13] divided the laparotomy findings into focal, multifocal and pan intestinal. In this study multifocal form came out as common (55%). However, in our study focal disease was comparatively more common to multifocal one. There were no cases with pan intestinal involvement in our study.

The findings exclusive to Stage 3 were pneumoperitoneum, ascites, focal collection and bowel wall thinning. All the cases of pneumoperitoneum were detected by X-ray and only 50% cases were detected by USG. But bowel wall thinning, ascites and focal fluid were detected by USG only. Sensitivity and specificity of USG in detecting these four exclusive findings of Stage 3 NEC were 93.8% and 86.9% respectively whereas X-ray had sensitivity of 18.8% and specificity of 96.4%. 32 out of 34 Stage 3 cases were operated, and all these cases showed classical gross appearance of NEC on laparotomy. Since ultrasound has got more sensitivity in identifying the findings, it is a more sensitive investigation in diagnosing cases requiring surgery when used along with relevant clinical findings.

Silva et al. in 2008 reported 100% correlation between abdominal USG findings of intraabdominal free air or focal fluid collection with the need for surgical intervention.[1] In the study "Diagnostic imaging features of necrotizing enterocolitis: a narrative review" by Francesco Esposito et al in 2016, the author concludes that even though imaging modality in the diagnosis of NEC is historically represented by the plain-film abdominal radiographs, abdominal USG in recent years is playing an increasingly important role in the evaluation of early stages of the disease.[14] According to Sharma et al, USG offers several advantages that can potentially contribute to an earlier diagnosis or, at least, provide more timely information about the stage of the intestinal wall condition.[15] In another study "Prognostic value of abdominal sonography in necrotizing enterocolitis of premature infants born before 33 weeks gestational age" by Garbi-Goutel A et al in 2014, concluded the usefulness of USG abdomen as a reliable tool for the prognostic assessment of NEC in preterm infants.[16] In 2017 the study by Palleri E et al, "Complex Fluid Collection on Abdominal Ultrasound Indicates Need for Surgery in Neonates with Necrotizing Enterocolitis" concludes that the Complex fluid collection shown with abdominal ultrasound appears to be strongly correlated to the need for surgery in new-born infants with severe NEC.[17]

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CONCLUSION

Results suggest that USG abdomen is more sensitive than X-ray abdomen in determining need for surgical intervention in neonates with necrotizing enterocolitis.

The sensitivity and specificity of USG abdomen in predicting need for surgical intervention in NEC is 93.8% and 86.9% respectively. The sensitivity and specificity of X-ray abdomen in predicting need for surgical intervention in NEC is 18.8% and 96.4% respectively.

Acknowledgement

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