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Predictive Value of Computed Tomography and Ultrasonography in Detection of Acute Appendicitis

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Predictive Value of Computed Tomography and Ultrasonography in Detection of Acute Appendicitis

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Dedication

This thesis is dedicated to my partners, my wife and my daughter, Zaina with love and gratitude

Declaration

I certify that this thesis submitted for the degree of Master, is the result of my own research, except where otherwise acknowledged, and that this study (or any part of the same) has not been submitted for a higher degree to any other university or institution.

Signed……

Ahmad Abdelrahman Mohammad Hussein

Date: 21/01/2020

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Abstract

Background and aims: Acute appendicitis is a common cause of acute abdominal pain. Its typical symptoms and signs were described already in the 1880s. However, the diagnostic work-up for patients with suspected acute appendicitis has dramatically changed over the last decades, especially after computed tomography was introduced in the 1990s. Diagnostic scoring provides an accurate method for stratifying patients according to the probability of appendicitis, and therefore works as an excellent basis for a diagnostic algorithm.

This study aimed to evaluate the predictive value of Ultrasonography (US) and abdominal Computed Tomography (CT) in the diagnosis of appendicitis, and to correlate US with CT a precious diagnosis of appendicitis and to evaluate the sensitivity and specificity of US and CT reports in detection appendicitis.

Patients and methods: The target population of this study were all the patient who were clinically suspected of having acute appendicitis and were admitted to the surgery department of Al Makassed, BeitJala, and Al-Isteshari Hospitals who underwent appendectomy surgery.

Study Design: A retrospective Observational Design was used for this research to determine the relationship between the US, abdominal CT reports and Histopathology reports for patients who were diagnosed with appendicitis after appendectomy.

Study setting: The studies presented in this thesis were conducted in three hospitals in Palestine; Al-Makassed Islamic Charitable Hospital which is one of biggest NGO hospitals in east Jerusalem, BeitJala Governmental Hospital which is one of biggest governmental hospitals in west bank, and Al-Isteshari Hospital which is a private hospital in the West Bank. This study was performed in radiology, surgery and pathological departments at the three hospitals.

Results: Of the 461 patients who were studied by US examination as a sole exam, or as a part of multiple radiological exam, the US showed inflamed appendicitis in 274 (59%), and showed a normal appendix in 46 (10%) while the US operator could not detect appendix in 141 (31%). The US showed an overall sensitivity of 89% and a specificity of 45%.

Seventy-one patients underwent CT scan (15 CT alone, 56 CT plus US). The CT showed an overall sensitivity of 91% and a specificity of 71%.

A total of 56 patients received both US and CT as a radiological modality for examination. Ten patients (18%) demonstrated a normal appendix on histopathogical exam and 46 patients (82%) demonstrate inflamed appendix on histopathology.

Discussion: In cases where the pathology report was positive for appendicitis, CT had a better value as it had a higher correlation rate over US. However, in negative pathology reports, CT had around 40% false positive rate.

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القيمة التنبؤية للتصوير الطبقي المقطعي والتصوير التلفزيوني في تحديد التهاب الزائدة الدودية

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الملخص

الخلفية والأهداف: التهاب الزائدة الدودية الحاد هو سبب شائع لآلام البطن. وقد وصفت الأعراض والعلامات النموذجية فعليا في عام 1880. ومع ذلك، فإن الإجراءات التشخيصية للحالات التي يشتبه بها بالإصابة بالتهاب الزائدة الدودية الحاد قد تغير بشكل كبير على مدى العقود الماضية، وخاصة بعد أن تم تطبيق التصوير المقطعي المحوسب في عام 1990. حيث توفر النتائج والطرق التشخيصية طريقة دقيقة لتقسيم المرضى وفقًا لاحتمالية التهاب الزائدة الدودية، وبالتالي فهي تعمل كأساس ممتاز لخوارزمية تشخيصية. تهدف هذه الدراسة إلى تقييم درجة دقة القيمة التنبؤية للتصوير التلفزيوني والتصوير الطبقي في الكشف عن التهاب الزائدة الدودية في مستشفى المقاصد، مستشفى بيت جالا الحكومي ومستشفى الاستشاري العربي ومقارنتها بتقارير التشريح النسيجي والمرضي للحالات بعد عملية استئصال الزائدة الدودية.

المرضى والطرق: جميع المرضى المستهدفين في هذه الدراسة هم المرضى الذين يشتبه سريريًا بإصابتهم بالتهاب الزائدة الدودية الحاد وقد تم ادخالهم الى اقسام الجراحة في مستشفيات المقاصد، بيت جالا والاستشاري الذين خضعوا لجراحة استئصال الزائدة الدودية.

تصميم الدراسة: تم استخدام تصميم ملاحظي بأثر رجعي لهذا البحث لتحديد العلاقة بين نتائج التصوير التلفزيوني والتصوير الاشعاعي المقطعي للبطن ونتائج التشريح النسيجي للمرضى الذين يشخصون بالتهاب الزائدة الدودية بعد جراحة استئصال الزائدة الدودية.

إعداد الدراسة: أجريت الدراسة المقدمة في هذه الرسالة في ثلاثة مستشفيات في فلسطين. مستشفى المقاصد الإسلامي الخيري وهو أحد أكبر مستشفيات الجمعيات الخيرية في القدس الشرقية، ومستشفى بيت جالا الحكومي وهو أحد أكبر المستشفيات الحكومية في الضفة الغربية، والمستشفى الاستشاري العربي وهو مستشفى خاص في الضفة الغربية. وتم إجراء هذه الدراسة في اقسام التصوير الطبي والجراحة وأقسام التشريح في المستشفيات المذكورة اعلاه.

النتائج: من بين 461 مريض تم دراستهم بواسطة الفحص التلفزيوني كإجراء وحيد، أو كجزء من فحوصات التصوير الطبي، حيث أظهرت نتائج التصوير التلفزيوني التهاب الزائدة الدودية في 274 (59٪) من الحالات، وأظهرت بان الزائدة دودية طبيعية في 46 (10٪) من الحالات بينما لم يستطع التصوير التلفزيوني القدرة بالكشف عن التهاب الزائدة الدودية في 141 (31٪) من الحالات. حيث كانت نسبة الحساسية الإجمالية للتصوير التلفزيوني 89٪ ودقة 45٪.

خضع واحد وسبعون مريضا لفحص التصوير الاشعاعي الطبقي، 15 حالة فقط خضعت للتصوير الطبقي بشكل مباشر ،56 حالة خضعت لكل من التصوير الطبقي والتصوير التلفزيوني. وقد أظهر التصوير الطبقي حساسية بنسبة 91% ونسبة دقة 71%. تلقى ما مجموعه 56 مريضا كل من التصوير التلفزيوني وكذلك التصوير الطبقي كطريقة للكشف عن الزائدة الدودية. أظهرت الدراسة أن عشرة مرضى (18٪) كانت الزائدة الدودية طبيعية و46 مريضا (82٪) أظهرت التهاب الزائدة الدودية.

النقاش: أظهرت نتائج دراستنا بأن كلا من التصوير التلفزيوني والتصوير الاشعاعي المقطعي أدوات ممتازة لتشخيص التهاب الزائدة الدودية.في الحالات التي أظهرت نتائج التشريح بأن الزائدة الدودية ملتهبة، سجل التصوير الطبقي نسبة دقه أعلى بالكشف عن الحالات التي تكون الزائدة الدودية ملتهبة بالمقارنة مع التصوير التلفزيوني، وفي الحالات التي كانت نتائج التشريح قد أظهرت بأن الزائدة الدودية طبيعية كانت نسبة الخطأ الإيجابي بحدود 40%.

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Abbreviations

US	Ultrasound Scanning
CT	Computed Tomography scan
MRI	Magnetic Resonance Imaging
SPSS	Statistical Package for Social Science
AIR	Appendicitis Inflammatory Response
RLQ	Right Lower Quadrant
CRP	C-Reactive Protein
WBC	White Blood Cell
CECT	Contrast Enhancement Computed Tomography
mSv	millisievert
IV	Intravenous

CHAPTER ONE

INTRODUCTION

1. Introduction

Acute abdominal pain is the most common case among emergency department patients. One of the most common pathologies behind acute abdominal pain, acute appendicitis, has systemically changed over the previous time period. Appendicitis is one of the common surgical diseases that need surgery in western states (1). The percentage of abdominal pain from total hospital admission patients is 25% (2).

In the past, the diagnosis of acute appendicitis was made based on the clinical examination supported by non-specific laboratory findings demonstrating the presence of inflammatory process such as leukocytosis, ESR and CRP.

This simple way of diagnosis led to a negative appendectomy with a rate range from 15-30% (3).

The difficulties in distinguishing the patients with appendicitis needing operating intervention from the patients with non- operating or spontaneously resolving abdominal distress, together with the goal to prevent and restrain complications, i.e. perforation of the appendix and peritonitis, has led to the traditional agreement of a relatively high rates of unnecessary surgery and removal of a healthy appendix (negative appendectomy). In children, a negative appendectomy average of 15-25% has been reported (4). Since unnecessary surgery is a squandering of medical resources, and the complication rate post negative appendectomy is very small (5), this practice is being increasingly misbelieved (6). Negative appendectomies lead to an excessive use of health resources for example hospital beds and operation rooms. In addition to economic and logistical respects, negative appendectomy is linked to comparable or higher complications as compared to appendectomy for uncomplicated appendicitis (7). A more limited surgical approach is supported by the evolution of advance imaging techniques, in specific ultrasonography and computed tomography The improvement of imaging modalities, particularly those of

computed tomography (CT), had allowed more precise diagnostics with a noteworthy reduction in false positive diagnoses, which had directed to lesser amounts of negative appendectomies (8). This development in diagnostic precision has been attained at the price of increasing usage of imaging studies (9).

Even though in a few organizations and regions imaging is considered obligatory for assumed acute appendicitis, in other organizations diagnostic imaging is still not used adequately (10). This type of variance in diagnostic methods has led to different rates of negative appendectomies. For example, a large observational research in The United Kingdom reported negative appendectomy percentages from 3.3% to 37% (11).

Despite negative investigation for assumed appendicitis is remote from mild, imaging is connected to some threats as well. In the lack of diagnostic strategies, imaging is sometimes over- or underused.

CT is the most precise imaging technique for the diagnostics of appendicitis but high use of CT includes higher budgets and higher hazards of related ionizing radiation and contrast medium, and a possible longer postponement to management. Abdominal organs are vulnerable to ionizing radiation, and assumed appendicitis is most common in young individuals for whom the considerations of radiation-induced risks are most significant (12).

After a preliminary uncontrolled surge in imaging, surgeons have successfully begun to discover methods of restraining the possibly injurious unselective CT imaging without compromising diagnostic precision (13). There is suggestion that using a diagnostic procedure or electronic choice support in assumed appendicitis is related to a reduced necessity of CT imaging studies without any loss of diagnostic precision (14).

Ultrasound (US) is frequently used as a main imaging technique to evade radiation induced by CT. If US is diagnostic for appendicitis, so the patient escapes the use of CT. If US is negative or non-diagnostic for appendicitis, the patient undertakes further CT. US includes

no ionizing radiation but its capability to identify or exclude appendicitis is lower to that of CT, and it is reliant on the abilities of the radiologists and the pre-test likelihood of appendicitis.

Additionally, US is often inconclusive due to body habitus, and operator dependent (15).

Diagnostic scale was initially discovered prior to the age of recent imaging technologies as an autonomous diagnostic instrument. Scoring has consequently frequently been merely inspected in the surgical literature as an alternate to imaging (16). Nevertheless, scoring and imaging must optimally be used as complementary approaches in a diagnostic process. The purpose is to achieve precise diagnosis with negligible hazards, delays, and prices in a consistent method independent of the knowledge level of the clinician. Recently, diagnostic scoring has been involved in consensus strategies of diagnosis of appendicitis (17).

Diagnostic scoring is a process for stratifying patients based on the likelihood of the patient having appendicitis. Characteristically patients are classified into three clusters: high, intermediate, and low risk for appendicitis. Generally, the patients in the low-risk category can be discharged, and patients in the high-risk category can be immediately planned for surgery. The patients in the intermediate-risk category profit best from more studies such as imaging.

There are numerous different diagnostic scores for assumed acute appendicitis. the Alvarado score is the most extensively recognized of these scores. The Alvarado score was initially established for both pediatric and geriatric patients, and contains eight clinical and laboratory variables (18). The Appendicitis Inflammatory Response Score (AIR) was published in 2008 and is comparable to the Alvarado score in numerous features but highlights the inflammatory response laboratory results, and appears to do better compared to the Alvarado score (19). None of the current scores has obtained prevailing acceptance in ordinary clinical practice. There are possibly a few reasons for this. The results of scoring schemes are often

compared to imaging results and are so incorrectly understood as being competitive and not complementary to imaging (16).

The discriminating ability per se of the present scoring systems has not been dependable enough. There are some probable features that weaken the accurateness of these scoring systems. First, the diagnostics of acute appendicitis is different in children of variable ages compared to adults, and several of the preceding scores are established for patients of all ages. The reference values of inflammatory laboratory variables and probable differential diagnoses rely on the patient's age (20). The exact time of beginning of symptoms, pain relocation, and other specifics of patient history are possibly not known in the youngest individuals. Second, the postponement in coming to hospital affects the results of inflammatory laboratory variables (21). Third, the diagnosis of appendicitis is more ambiguous in female patients (6). These three significant confusing features have not been taken into account in formerly described scoring systems.

In this thesis, the diagnostic accuracy of Ultrasonography and Computed Tomography was investigated and compared with histopathology result after appendectomy.

1.1 Problem Statement

Appendicitis is one of the most common surgical diseases that need intervention to avoid perforation of appendix and its complications.

1.2 Study question

Can Ultrasonography and Abdominal Computed Tomography be considered good indications of acute appendicitis and reduce range of negative appendectomies?

1.3 Justification

The diagnostic accuracy of US and abdominal CT is desirable to avoid unnecessary laparotomies and negative appendectomy.

1.4 Purpose

To evaluate accuracy of US and abdominal CT reports predictive value in detecting appendicitis at Al-Makassed Charitable hospital, BeitJala Governmental hospital, and Alisteshari Private hospital and correlate it with histopathology reports.

1.5 Objectives and Aims

To evaluate the predictive value of Ultrasonography (US) and abdominal Computed Tomography (CT) in the diagnosis of appendicitis at Al-Makassed Hospital, BeitJala Governmental Hospital, and Alisteshari Private Hospital, three different health sectors.

To evaluate the diagnostic precision of US and of abdominal CT in the diagnosis of appendicitis.

To correlate US with CT a precious diagnosis of appendicitis.

To evaluate the sensitivity and specificity of US and CT reports in detection appendicitis.

CHAPTER TOW

REVIEW OF THE LITERATURE

2. Review of the literature

There are signs that appendicitis was present in 3000 B.C., as adhesions in the right lower quadrant of the abdomen, toughly suggestive of appendicitis, were discovered in one Egyptian mummy (22). In 1554, a French physician Jean Fernel, funded the initial documented explanation of appendicitis in a 7-year-old girl, who pass away of perforated appendicitis, and he named the disease "passion iliac" (23).

In the 1800s, the disease that is today identified as appendicitis went by with several terms including "peri-caecal inflammation", "typhlitis", "perityphlitis", and "paratyphlitis". in 1886, Dr. Reginald Fitz first defined appendicitis and advised its treatment by initial appendectomy in his article "Perforating inflammation of vermiform appendix" (24). At that moment, patients with generalized peritonitis ordinarily died, while abdominal abscesses might be drained. Non-surgical procedure as we recognize today was practically non-existent without intravenous solutions, antibiotics or vasopressors presence available (25). In 1891, Charles McBurney published his paper "The indications for early laparotomy in appendicitis", where he defined characteristic symptoms and discoveries of appendicitis. The significant medical symptoms and signs in McBurney's paper were the severe onset of abdominal pain, limitation and specific pain from general abdomen to the right iliac fossa, the most pain localization terminated the base of appendix, fever, tachycardia, and guarding. He defined a main point, later known as the "McBurney point", where the pain from appendicitis is limited.

In 1894, Before McBurney printed his paper entitled: "The incision made in the abdominal wall in cases of appendicitis, with a description of a new method of operating" the surgery for appendicitis was done through a midline cut or para median cut above the linea semilunaris (26). The oblique cut used in open operation for appendicitis through decades

developed identified as the McBurney incision after the paper although it was not firstly invented by McBurney (27).

Mortality rate was high from appendicitis and appendectomy. Later the date of McBurney, the operation for appendicitis stayed technically carefully like to current open operation, but growth of hospitals and non-operative procedure containing antibiotics and anesthesia, both with superior entrance to health care have prepared appendicitis a benign illness with a small mortality rate.

In the first of 1980s, Semm defined appendectomy that was carried out using an endoscopic technique earlier used by gynecologists during operating pelviscopy (28). Laparoscopic appendectomy gradually became more public, and is now the standard procedure for appendicitis (29).

In Sweden, appendectomy was presented as healing for acute appendicitis by Karl Gustaf Lennander in Uppsala in 1889. The total of appendectomies performed increased quickly from 618 in 1901 to 10,449 in 1913 in Sweden (30).

Medical symptoms and signs already mentioned to by McBurney remained the foundation of diagnostics for periods. Blood leukocytosis and enlarged amount of neutrophils was late found to be related with appendicitis (31). Immediate surgery appropriate to avoid perforation was the gold ordinary, and false positive finding of 15-30% was measured normal (32).

In 1986, Alfredo Alvarado issued the Alvarado Score, an investigative score for the initial evaluation of acute appendicitis. The score contains 8 elements: migration of pain, anorexia, nausea, tenderness in the right lower quadrant of abdomen, rebound pain, raised temperature, blood leukocytosis and move to the left. The score grouped patients with suspected appendicitis into three category depend on the possibility of appendicitis, so aiding in the decision-making (18).

The technological improvement of imaging techniques followed, which enhanced diagnostic accuracy and therefore the usage of evaluating imaging developed general in assumed acute appendicitis. In some organizations, diagnostic imaging techniques is currently considered obligatory. Now, the characteristic frequency of false positive diagnosis is nearby 10% but unlimited variation in percentage still occurs (10).

2.1 Etiology, Pathogenesis, and Classifications

The vermiform appendix and the caecum grow from the caecal bud, that rises out of the antemesenteric edge of the caudal limb of midgut loop near the start of the sixth gestational week (33). It stays at the end of the caecum till birth but reaches its last location on the posteriomedial wall under the ileocecal valve because the lateral caecal wall is growing earlier than the medial. The anterior and the retrocaecal location have been labelled as most common by many authors (34). Varying grades of malrotation might cause more ectopic sites of the appendix (sub-hepatic and intracaecal) (35).

The normal appendix measurement is 9 cm. The appendix has the similar elementary constructions as the colon (36). Nevertheless, growth of lymphoid tissue approximating the organization in the distal small intestine happens rapidly following birth and continues throughout childhood, till around the age of 25 years. The extreme transverse diameter is stated to be reached by 4 years and declines progressively afterwards, because of the involution of the lymphoid tissue and growing fibrosis (34).

The generally acknowledged opinion is that the appendix is a vestigial organ with no purpose. It has been proposed that there is a link with food behaviors, since an appendix-like tissue is apparent in other omnivores than humans (37).

The appendix has also been suggested to have a role in the movement of the colon (38) or for the immunological defenses, but these ideas stay unverified.

The cause of appendicitis stays unidentified. The most preferred model and surgical references explain that the chief cause of appendicitis is impediment of the lumen of the appendix produced by fecolith, lymphoid hyperplasia or cancer, followed by secondary bacterial attack of the appendiceal wall which ultimately cause necrosis and puncture when not managed on time (39).

Faecoliths or appendicoliths, considered as likely reasons of hindrance, are more commonly noticed by means of up-to-date imaging methods, particularly CT. They seem more commonly related with punctured appendicitis and might consequently embody a probable danger for perforation (40); faecoliths might likewise be an accompanying result when inflammation is inattentive (41).

Past investigational research that were previously performed in animals and far ahead also in humans, concluded that blockade of the lumen of the appendix caused augmented intraluminal burden, which endangered the sustainability of the appendix (42). Nonetheless, up-to-date researches on the cause of appendicitis do not upkeep this theory. The incidence of fecolith in adult subjects in a research by Singh and Mariadason was 13.7% and 31.6% for appendicitis and negative appendectomy samples, respectively. The frequency of fecolith was 27.5% in perforated appendicitis paralleled to 12.0% in non-perforated appendicitis (43). A study of 101 post-mortem appendices and more than 3000 surgically removed appendices found fecolith in 27% of autopsies, yet inflammation was noticed in not any of these samples (44). A research of the histopathology of appendix in New Zealand stated lymphoid hyperplasia to be more prevalent in normal than inflamed appendices, and ensued only in 6% of 1711 appendices in which acute inflammation was noticed (45).

Several alternate reasons of appendicitis have been proposed, i.e. primary infection of the appendix, either hematogenous or coming from a crack of the mucosal wall (46), or a result of a preceding collapse of the mucosal wall with a subclinical infection, causing a restriction

(47). A periodic alteration in frequency and cluster eruptions of appendicitis, as well as the age scattering with a frequency topmost in adolescence, look like that of numerous communicable illnesses, particularly tonsillitis and influenza (48), but a causative relation has not been confirmed. There are sequences of precise infections of the appendix stated difficult to vary from usual acute appendicitis. viral infections have been proposed as an etiological aspect because of periodic difference in the frequency of appendicitis but this theory stays unverified (49). A few bacterial infections can lead to appendicitis with or without participation of the intestine (50). Parasitic infections are a recognized likely etiological issue of acute appendicitis particularly in developing regions.

Enterobius vermicularis (pinworm) that is usual also in developed regions is the most mutual worm found in the appendix (51). Besides infrequently producing appendicitis, pinworm may also lead to appendicitis-like cases that cause appendectomy (52). And actinomyces, tuberculosis, Helicobacter jejuni, and Yersinia enterocolica amid others (41). Other infrequent described reasons of appendicitis are swallowed foreign objects such as shotgun bits from wild game can travel to the appendix and lead to inflammation accompanied or not accompanied with perforation, and trauma (53).

To summarize, the exact cause of appendicitis stays unidentified, but numerous likely helping aspects have been documented or is multifactorial.

2.2 Epidemiology

The diagnosis of appendicitis is not permanently confirmed by histopathology and hereafter, an assessment of the epidemiology of appendicitis is problematic. It is usually supposed that the frequency of appendectomy imitates the occurrence of appendicitis, but this hypothesis is debatable (33).

Acute appendicitis happens in all age groups but there is a noticeable rise in the twenties of age (54). Around one tenth of all affected people are aged less than 10 years and another tenth are aged more than 50 years (46). Acute appendicitis happens also in pediatrics, although the condition is infrequent below the age of two years (55).

Appendicitis is 15% to 48% more frequent in men and the sex variance is noticeable in all ages. From the United States, ethnic variances have been described with a 50% lesser frequency in blacks and Asians compared to Caucasians (54). A family history of appendicitis seems to be an important risk factor (56). Contemporary appendicitis in first degree relatives was described, representing both a genetic vulnerability and an environmental effect (57). Breastfeeding in pediatrics may have a shielding consequence as youngsters who were breastfed for a period of 7 months or more had a 40% lesser probability of appendicitis than those who were not breastfed (58).

All life risk of getting appendicitis, depending on information from the United States 1970-1984 is around 9% for men and 7% for women, and lifetime risk of appendectomy is 12% for men and 23% for women (54).

2.3 Uncomplicated appendicitis

Uncomplicated appendicitis (also known as suppurative appendicitis and simple appendicitis) is defined as acute inflammation of a part or all the appendix. The mucosa of the appendix is intensely inflamed and frequently ulcerated.

Transmural inflammation, vascular thrombosis, and intramural abscesses are characteristic. Gangrenous acute appendicitis is occasionally encompassed under the description of uncomplicated, and sometimes it is encompassed under complicated appendicitis, according to the source (Fig. 2.1) (59).

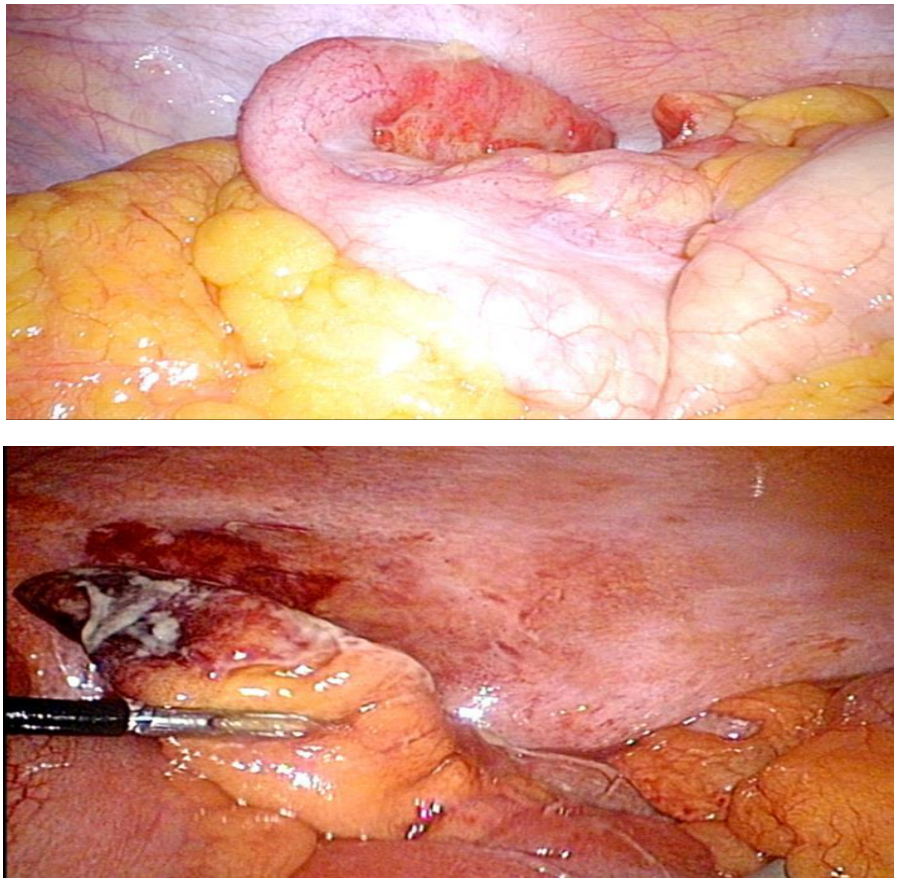

Fig.2.1: Laparoscopic images of uncomplicated appendicitis

2.4 Complicated appendicitis

Complicated appendicitis is defined in many ways. The traditional definition is appendicitis with perforation and peritonitis or appendiceal abscess.

The perforation frequency is more in children (23-73%) (4) and in the old (55-70%) (60), who are believed to have an inferior opposition to perforation or a more quickly advancing illness (61). Subjects who have a late diagnosis have a high perforation frequency (62). These subjects frequently have simultaneous diseases and uncertain clinical symptoms (63). In pediatrics, there is often a postponement before being transported to medical care (64). About one third of subjects are considered to have atypical clinical results (4). Additionally, children may be problematic to inspect and may be incapable to transfer their illnesses (65). It has also been advised, that the thinner appendiceal wall in pediatrics may result in a quicker evolution of appendicitis to perforation (66).

Radiological diagnosis of perforation is indefinite, and the most precise radiological indications to perforation include extraluminal gas, focal imperfection in appendiceal wall, abscess and small bowel ileus (67). A study examined clinical and radiological properties of complicated appendicitis, and concluded in a scoring scheme which categorized uncomplicated and complicated appendicitis that was more dependable than only using imaging (68).

2.5 Negative appendectomy

Negative appendectomy is appendectomy undertaken for doubted appendicitis with no appendicitis found, even when additional essential surgical action is performed throughout the same procedure (69).

The total frequency of negative appendectomies has decayed since 1990s as a result of more precise diagnosis that has largely resulted from the expansion and wider application of imaging techniques (8). A negative appendectomy frequency of 20% or more was regarded satisfactory before the time of CT (70). Now, negative appendectomy frequency of about 10% or less is regarded satisfactory, but the rate still differs critically (10). In spite of the development of up-to-date imaging, diagnostic approaches are still not 100% precise and so the frequency of negative appendectomy will persist above 0%. Appendectomy is a fairly safe routine process, but there is related morbidity. Complications are at least as frequent in negative investigations as in therapeutic processes; approximately 10% of cases (7).

Evading needless laparotomies has become progressively necessary, since the complication percentage is not insignificant and is even greater with negative laparotomy, as compared to positive. The higher risk of having small bowel obstruction post a negative appendectomy may be due to both the surgical practice (5) and to patient-related features, i.e. higher inflammatory reaction (71). Economic concerns on the negative appendectomy frequency

have also become gradually more important, since avoidable surgery is a loss of medical resources (72).

2.6 Clinical course

Typically, the disease starts with a visceral pain situated near the epigastric area. After some time period, but generally within 6-18 hours, the pain travels distally to the right lower quadrant of the abdomen and a continual, discrete tenderness progresses, due to the peritoneal involvement. Rebound tenderness, as well as both involuntary and voluntary muscular contraction, can also be found. Other symptoms like anorexia, nausea, vomiting, constipation or diarrhea may be present.

Untreated appendicitis is believed to ensue to perforation in a high percentage of cases. Perforation might end in short-term relief of pain, but is then tailed by a steady rise in severity of the symptoms (36).

Related complications comprise peritonitis as well as septicaemia. In about 2-3% of cases with acute appendicitis, perforation is tailed by the occurrence of a appendiceal abscess (73). The appendiceal abscess development is also thought to happen without a noticeable rupture of the appendiceal wall, as bacteria may eagerly infuse an injured appendiceal wall (74).

The disease evolution continues regularly throughout 8-48 hours; if the case is not diagnosed as appendicitis within this time period, the likelihood that it truly is appendicitis is gradually decreased (36). An advanced appendiceal abscess might have a history of less clear symptoms over several weeks. Naturally resolving appendicitis has been described. Recurring and chronic types of appendicitis have also been documented (75).

The above mentioned presentation is seen in only two thirds of the subjects with appendicitis, and subjects with other abdominal illnesses may have comparable symptoms (76). The inconsistency in the exact anatomical position of the appendix affects the localized symptoms. Children are more frequently thought to show up with atypical presentation (4).

2.7 Diagnosis of Acute Appendicitis

2.7.1 History:

Knowing the clinical course of appendicitis is obligatory for satisfactory history taking. In pediatrics, there are substantial problems present; pediatrics, especially, may be unable to understand and answer questions in a clear way (7), which might add a postponement before being taken to medical care (64).

2.7.2 Clinical symptoms and physical examination:

Typical symptoms and signs of appendicitis have been known to physicians for more than a hundred years, and continue to be the most significant part of the assessment of people with acute abdominal pain (24). None of symptoms, signs or tests is completely precise in diagnosing appendicitis, but a mixture of numerous results support the diagnosis. Before the time of CT, the choice to perform a surgery in suspected appendicitis was grounded on clinical signs and findings reinforced by laboratory inspections, and the described negative appendectomy frequency was usually 15-30% (9, 13).

The most distinctive symptoms of acute appendicitis comprise acute abdominal pain in the right lower quadrant (RLQ), transfer of pain from higher part of the abdomen to the RLQ, loss of appetite and nausea, and fever.

The pain may be worsened by motion or cough indicating peritoneal inflammation, with or without vomiting (18, 19).

Tenderness in the RLQ is the most frequently discovered sign in the physical examination, but this sign is not found in all of cases.

Peritoneal inflammation as a result of appendicular inflammation can be verified in several different methods, of which the mixture of guarding and rebound tenderness (also known as Blomberg's sign) is the most precise sign. Indirect tenderness in Rovsing's test aids the diagnosis and so does the psoas sign which indicates irritation to the iliopsoas muscle and

that the inflamed appendix is located in the retrocaecal site. Patients frequently have a higher temperature (18, 81).

2.7.3 Laboratory findings:

Numerous diagnostic laboratory results that quantify inflammatory process are independently related to appendicitis. This relation is as strong as the relationship of characteristic clinical results such as guarding and rebound tenderness. Though, inflammatory laboratory inspections, as well as clinical symptoms and results, have the solidest relations with appendicitis when they are added to each other (71). There exist no laboratory inspections, dependent or not on each other that have 100% positive or negative foretelling results for appendicitis (21). Blood leukocyte count, the fraction of polymorphonuclear cells, and C-reactive protein (CRP) are usually used in clinical application for assumed appendicitis, but several others have also been tested.

Raise of the leukocyte number is an autonomous prognostic element of acute appendicitis, and starts in the initial stage of the disease (6). The whole white blood cell count (WBC) is typically raised to more than 9.0×10^{9} /L. Repetitive quantification have revealed that WBC might decline and even be normal in spite of the unceasing process of inflammation (77).

The higher percentage of polymorphonuclear cells (neutrophils, eosinophils and basophils), and higher percentage of neutrophils are recognized to be related to appendicitis (6, 18). Current investigation proposes that higher neutrophil-to-lymphocyte fraction is a predictor of acuteness of appendicitis (88).

Raised CRP value is related to appendicitis (71). Nevertheless, the comparatively slow initiation of CRP confines its worth in the finding of acute appendicitis in the initial stage of the disease, and even within-range numbers of CRP do not consequently exclude possible appendicitis. CRP numbers beyond 10 mg/L may be valuable in clinical treatments of infections, containing appendicitis (79).

2.7.4 Other laboratory values:

Bilirubin, Urine analysis.

2.7.5 Laparoscopy:

Laparoscopy has been defined as a cost-effective process in the diagnosis and management of abdominal pain in subjects with uncertain cause and particularly when appendicitis is assumed. However, laparoscopy is an invasive process needful of anaesthesia, and is related to a risk for complications (80).

2.8 Radiologic imaging

The technological expansion of imaging techniques has allowed imaging to play a growing and even vital role in diagnosis of acute appendicitis.

Nowadays, imaging for doubted appendicitis is even considered obligatory in several organizations (10).

2.8.1 Plain radiographs and barium enema:

Earlier to the age of CT, routine abdomen X-ray was commonly used in diagnostics of acute abdominal pain. The signs that were used to aid diagnosis of acute appendicitis by X-ray were appendicolith, RLQ soft tissue bulk, extraluminal air, psoas margin obscuration, and levoconvex lumbar spine scoliosis. The diagnostic accurateness of routine abdomen X-ray is fragile, and this imaging technique cannot be suggested in the diagnosis of acute appendicitis (81).

Routine abdominal x-ray and barium enema are inaccurate and of little importance. Radiographs were described to have inaccurate results in 75% of pediatric subjects with appendicitis in one study (82), whereas other studies found x-rays useful in only 6% of times (83). Filling of the appendix completely with contrast almost rules out appendicitis, while non-filling of the appendix with bulk effect on the caecum advocates appendicitis. Nevertheless, the appendix does not fill entirely in 8% of normal subjects (84).

Additionally, evaluation of whole filling can be hard because of the difference in the size of normal appendices and difference in the level of block in appendicitis. Other situations than appendicitis can cause mass effect on the cecum (85). Currently, routine radiographs and barium enema have been substituted by up-to-date imaging methods with more sensitivity and specificity.

2.8.2 Ultrasonography (US):

Ultrasound can be utilized in diagnosis of acute appendicitis. This method was first defined by Pulyaert in 1986. Graded compression is utilized to displace gas-containing intestinal loops to see the uncompressible inflamed appendix. Typical diagnostic structures of appendicitis in graded compression US contain local probe tenderness, uncompressible solidified appendix and peri-appendiceal fat permeation (86). Fig. (2.2) shows a characteristic US image of an inflamed appendix.

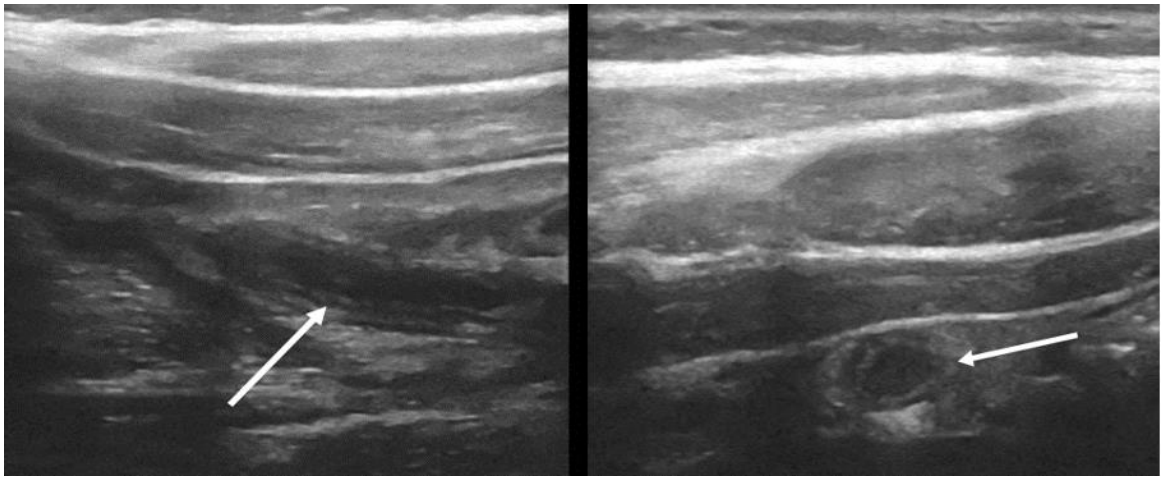

Fig. 2.2: US images of appendicitis (the arrows point at the appendix).

The total sensitivity of US differs in diverse studies, but frequently lies in the range of 75-95% (87); still, numbers as low as 44% have been described (88). The specificity of US is typically described to lie within the range of 90-95%, though considerably inferior numbers have been stated (87). The diagnosis of appendicitis is dependent on the discovery of a

blind-ending, non-compressible tubular structure with a greatest diameter beyond 6 mm, with or without an appendicolith, and with no peristaltic motion.

Doplex imaging might reveal hyperemia in the appendiceal wall that is considered as a discovery of high specificity (89); nevertheless, measurable hyperemia might be not present in initial and in advanced, gangrenous appendicitis (4). Presently, there are no studies on the usage of contrast-enhanced ultrasonography in the assessment of appendicitis. Fig. (2.3). Fig. (2.4)

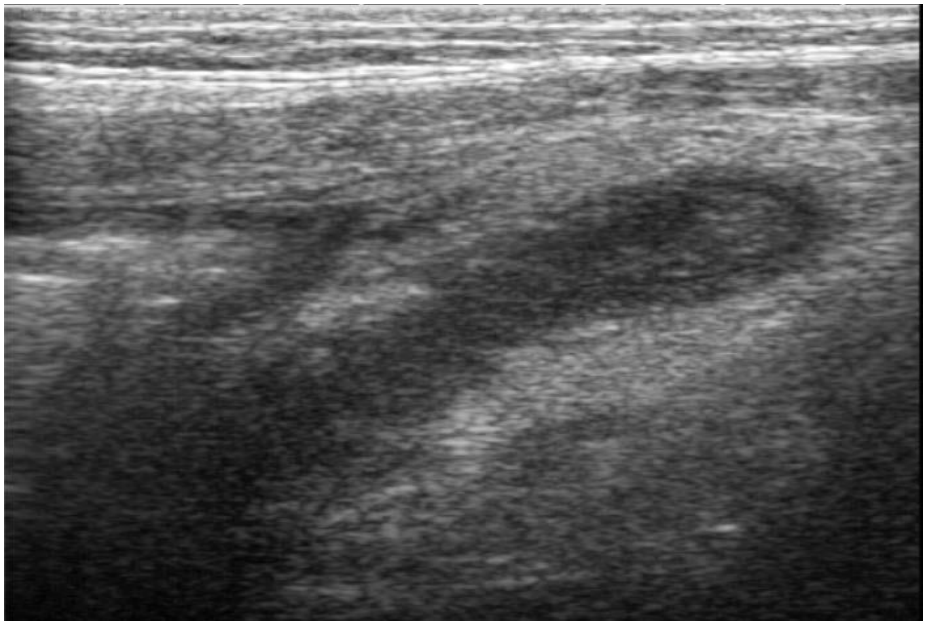

Fig. 2.3: Ultrasonographic longitudinal image of a gangrenous appendicitis.

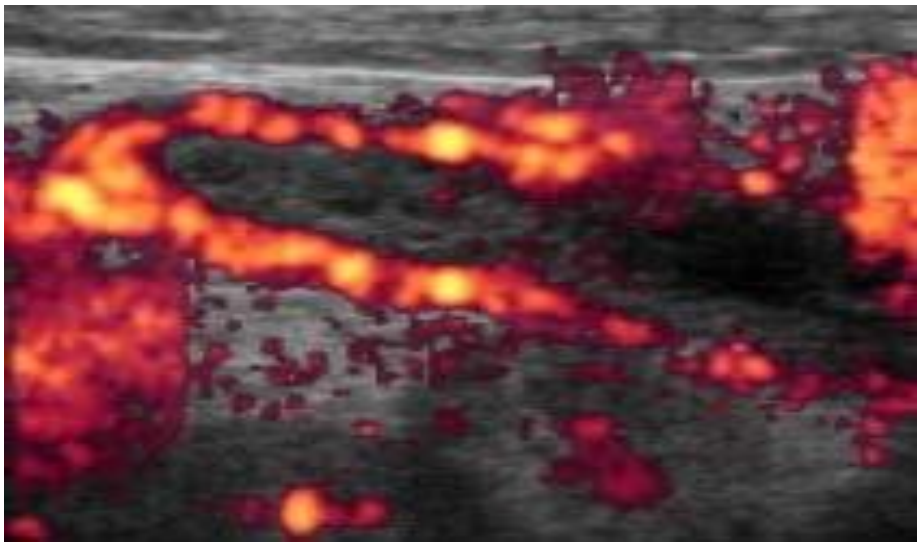

Fig. 2.4: Phlegmonous appendicitis. Color Doppler ultrasonographic image demonstrating mural hyperemia.

The main restriction of US is that is highly dependent on the operator, as shown by the extensive range of sensitivity and specificity numbers in diverse researches (89). An additional restriction of US in identifying appendicitis is that the absence of visualization of the appendix does not exclude appendicitis. Well-known problems in recognizing the appendix may happen in subjects with pain, overweight, superimposing gas, or in punctured appendicitis. Numerous new studies have confirmed that a normal appendix may be seen in a high count of subjects with symptoms indicative of appendicitis (4); this discovery is considered as very specific in eliminating appendicitis (89).

In youngsters, though, the smaller quantity of intra-abdominal fat compared to that in grownups might affect the capability to recognize the normal appendix and also to differentiate it from intestinal loops. The external diameter of the appendix has been a topic of argument.

Rettenbacher et al (90) established a noticeable overlap of external appendiceal width in normal and abnormal appendices, and decided that an external diameter of more than 6 mm as a mark of acute appendicitis offers high sensitivity but incomplete specificity. Hahn et al (91) described lymphoid hyperplasia as a reason of a sonographically abnormal appendix. In youngsters, the mucosa and submucosa are normally thicker (92), which can clarify the comparatively bigger count of false-positive US investigations described by some studies (93). A few cases considered as false-positive in many studies might also characterize naturally resolving appendicitis (75).

The high advantage of US as the main imaging technique is the fact that it is comparatively rapid to accomplish and does not include the administration of ionizing radiation, which is of high value in pediatrics (94).

Lymphoid hyperplasia may be misleading for diagnosing appendicitis particularly in pediatrics as it leads to a thickening of the appendix. The occurrence of other typical findings of appendicitis make diagnosis more dependable (95).

2.8.3 Computed Tomography (CT):

Spiral computed tomography with use of a diversity of methods has been described to be very sensitive and specific for the identification of appendicitis (81). The stated general sensitivity and the specificity falls typically within the range of 90-100% and 91-99%, respectively (4) although many techniques have been used in the numerous studies.

CT for assumed acute appendicitis was presented in the nineties. Research that links negative appendectomy rates before and after the application of CT shows a certain relationship between higher use of CT and reduced percentage of negative appendectomies (81). Nonetheless, the overall advantage of CT has been interrogated in a number of studies (96). Generally, intravenous contrast-media is utilized without oral contrast medium. Usual signs of appendicitis in CT images comprise thickening of the appendiceal wall with peri-appendiceal fat infiltration, appendiceal enhancement and peri-appendiceal free fluid (81). Fig. (2.5).

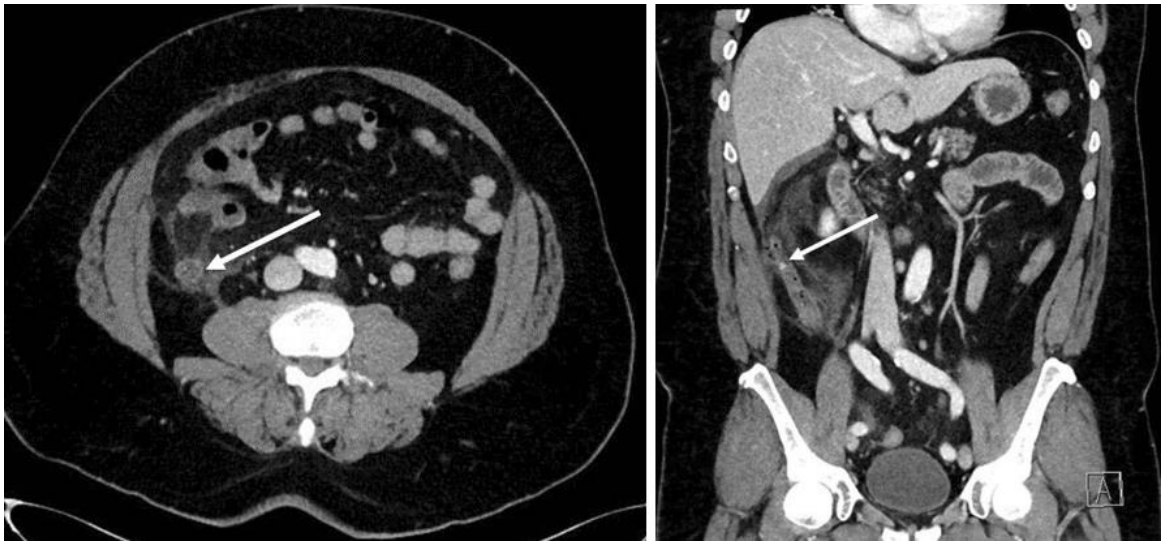

Fig. 2.5: CT images of appendicitis. The arrows point at the inflamed appendix.

The performance of CT as a diagnostic modality for appendicitis has been analyzed in numerous studies. In the 2010s, the reported specificity has been 93-98 % and the reported sensitivity has been 94-98.5% (97).

Despite the excellent performance of CT in diagnosis of appendicitis, the ability to differentiate complicated from uncomplicated cases has not been well reliable.

Findings on CT to suggest complicated appendix are mural defect, free gas, abscess formation, peri-appendieal free fluid and appendicolith.

These findings have the highest specificity, but it has a low sensitivity of 28-70% (67). However, the causal association of fecolith to advanced pathology is controversial (43).

Atema et al. have suggested a scoring system to increase the accuracy based on combination of clinical and imaging findings (21).

Several medical institutions have now accepted CT as the first diagnostic method because of its superior advantages over the US, these advantages include no operator dependency, superior visualization of the appendix and better determination of the complications (98).

In some hospital-based protocols, CT is performed on all suspected cases of appendicitis. Concerns about the risks of ionizing radiation and possible reactions to the contrast media, and the high cost of this procedure have led to a protocols with more selective in choice CT as the first diagnostic method and to use low-dose protocols when it needed.

The radiological diagnosis of appendicitis is based on the visualization of dilated (>6mm in maximum diameter) non-compressible appendix with or without appendicolith, with mural enhancement in Contrast Enhancement CT (CECT) Fig. (2.6), and/or surrounding inflammatory process and abscess visualization in complicated cases (99).

In patients with abdominal symptoms caused by alternative pathologies, the accurate identification of normal appendix is valuable. However, it is not always possible to identify

it, especially in patients with small amount of intraperitoneal fat, particularly, children younger than 10 years (100).

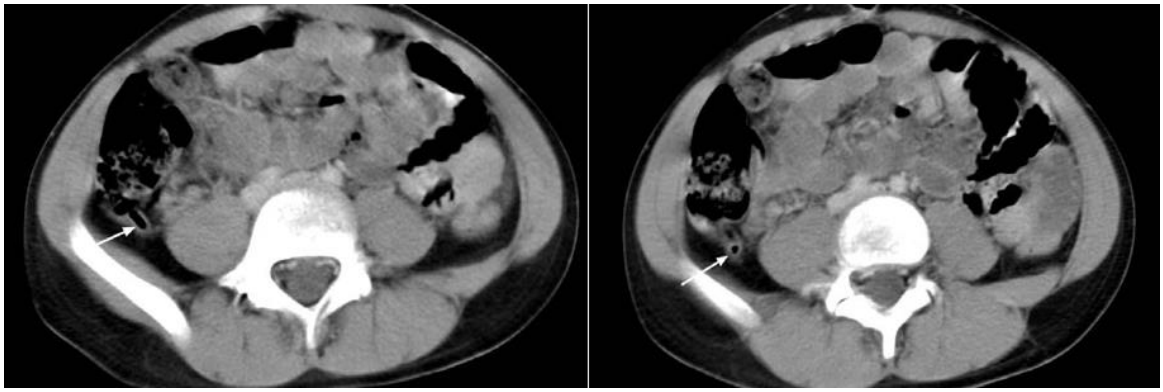

Fig. 2.6: Two consecutive abdominal CECT scans demonstrating a normal air-filled appendix (arrows).

Recently, developing malignancy as stochastic effect from the ionizing radiation is a well-established risk (94). Pediatric are at greater risk, because of the longer life span and the increased the sensitivity of the dividing cells.

A major concern is the radiation-induced risks from CT scanning because of its frequent utilization. Mettler et al found that CT were responsible to 67% of the effective dose from all diagnostic images, from all scans, 11% were performed in pediatrics (101).

Paterson et al. stated that most of CT procedures executed at many organizations did not use methods suitable for children, which comprised both issues resulting in higher radiation dose and issues reducing diagnostic accurateness (102). A case of a non-medical action that rises radiation contact is high altitude flying. It was expected that 10,000 miles of long airline travel leads to higher cancer risk for pediatrics of 1 in 5,000 (103), which is comparable to the single CT risk estimated, using the contemporary lower dose techniques.

Consequently, CT scanning should be asked for with care to both the hazard and the advantage. In most instances, the advantage highly offsets the risk. All CT images should be executed using the least dose that gives the radiologist with needed information (104). Donnelly et al. defined a table that may be used to select the single-detector CT scanning

method for tuning the radiation dose, according to the region of the body imaged and to the patient's weight. The utilization of this method in pediatrics gives a reduction in radiation dose of around 75% with sufficient diagnostic accuracy (105).

Techniques for dose saving for multidetector CT are also being progressively developed. Nevertheless, the highest possible reduction in hazard happens when a needless procedure is not executed.

Assessments of US and CT for diagnostic value are ambiguous. US has revealed lesser diagnostic value compared to CT in comparative procedures, despite that identical diagnostic performance were stated in earlier research. However, US includes no ionizing radiation or contrast material, and the expense of US examination is less compared to CTs. The sensitivity and specificity of US were 76-88% and 93-95%, respectively (106). The appendix is not continually noticeable in US examination, and consequently negative US result does not constantly exclude appendicitis. Yet, the positive prognostic value of US is useful. This, added to the goal of evading additional ionizing radiation led to the utilization of US as a chief imaging technique in most organizations. Though, in the case of questionable or negative US, CT is essential (21).

2.8.4 Magnetic Resonance Imaging (MRI):

Magnetic Resonance Imaging (MRI) results linked to acute appendicitis comprise appendiceal diameter of more than 7 mm, fat infiltration around the appendix and limited appendiceal wall diffusion (107). The diagnostic value of MRI in assumed appendicitis is higher than US but lower than CT. The MRI does not include ionizing radiation, and can be applied even in pregnancy and perfect soft tissue resolution, multiplanar imaging proficiency. MRI is frequently used to substitute CT for pregnant women after questionable or negative US. The stated sensitivity and specificity of MRI are around 82-98% and 71-

100%, respectively, according to the skill of the MRI technician. Though, MRI is not precise at identifying perforation of the appendix (108).

The technique has numerous restrictions; for example, high expense, time-consumption and consequently normally needs sedatives in youngsters, and is infrequently accessible an emergency. Additionally, as faecoliths and abdominal gas give analogous signal voids on MRI, they might be hard to differentiate.

2.9 Risks of ionizing radiation

The exact dangers of radiation resulting from diagnostic imaging are unidentified, but approximations based on research can be found. The cancer risk related to a CT procedure is little but existing. Visceral organs are sensitive to exposure to ionizing radiation, and assumed appendicitis is most common in young subjects with which the issues of radiation-induced dangers are most significant (12). An investigation of radiation-induced cancer related to assumed appendicitis by Rogers et al. unenthusiastically decided that if all subjects with doubted appendicitis undergo CT, one cancer death will happen as an expense for every 12 evaded negative appendectomies (109). Another approximation given by investigators was that about 2000 CT scans on young adult patients suspected of acute appendicitis would lead to at least one death due to cancer (110).

Low-dose procedures for abdominal CT had been created to decrease radiation dose of CT for suspected appendicitis. The usual stated reference ranges for the effective radiation doses for typical abdominal CT are from 7 to 10 mSv, while the radiation doses of low-dose procedures can be as low as 2 mSv (111). Researches display similar diagnostic results for low-dose CT compared to standard-dose CT in detection of acute appendicitis, and diagnostic procedures including low-dose CT protocols as a part of diagnostic plan have been effectively accepted (15).

Numerous organizations have partially substituted CT by US in order to decrease hazards of ionizing radiation. Therefore, US is used as the first line imaging technique for all subjects in these situations, and CT is executed when US is negative or questionable (8, 10). Equal or better diagnostic results has been described in conditional versus immediate CT procedures using US as the main imaging technique. In addition to better safety, conditional CT gives economic benefits (21). A randomized research described that selective CT imaging depending on clinical evaluation was cost-effective in comparison to routine CT (112).

2.10 Differential diagnosis

Numerous circumstances resemble acute appendicitis. The diagnosis is greatest puzzling in fertile-aged females with likely acute symptoms of gynecological source. Other cases that are frequently mistaken for appendicitis comprise mesenteric adenitis, gastroenteritis and acute diverticulitis (32, 71).

2.11 Treatment of appendicitis

2.11.1 Appendectomy:

For over a 100 years the best management of acute uncomplicated appendicitis has been rapid appendectomy to avoid perforation of the appendix (26).

Open appendectomy is the management of choice in the massive majority of subjects with appendicitis. The surgical method applied nowadays has grown from tradition and practice over many decades. Laparoscopic appendectomy was done for the first time in 1983, and is now done regularly at many organizations, in both adults and pediatrics. Laparoscopic appendectomy gradually became more prevalent, and is nowadays the standard procedure in surgery for appendicitis (29).

2.11.2 Laparoscopic versus open appendectomy:

Many researches have revealed that the laparoscopic method have benefits for people with non-complicated and complicated appendicitis, in the old, people with comorbidities, and in overweight patients. There is less complications and smaller length of hospitalization post laparoscopic operations for all people (29). A Swiss analysis of 7446 people that performed laparoscopic appendectomy for acute appendicitis over the period of 1995-2008 revealed there was a significant reduction in postoperative complications, repeated operations, and the duration of hospital stay over the 12-year analysis period (113). A population based analysis from Finland stated that open appendectomy was led to six-fold increase in mortality compared to laparoscopic appendectomy (114). Fig. (2.7).

Fig. 2.7: Operation room image of laparoscopic appendectomy.

2.11.3 Conservative treatment:

Conservative management with antibiotics (combined Intravenous (IV) and oral antibiotics) has been utilized in acute appendicitis in small adult populations (77) but there are no researches limited to pediatrics. Antibiotic management that might or might not be tailed by an appendectomy, nevertheless, is often used in the treatment of appendiceal abscesses; occasionally in addition to drainage of the abscess. Prophylactic antibiotic management,

earlier to an appendectomy, is suggested particularly in situations of progressive appendicitis (115). One randomized controlled study associated conservative management and direct laparoscopic surgery and established that laparoscopic surgery is harmless in knowledgeable hands and related to less readmissions and further interventions (116).

There is agreement that the period of time between the beginning of symptoms to the treatment is connected with the severity of appendicitis, and that lengthy time to management causes perioperative complications (117).

2.12 Histopathologic analysis

The commonly known histologic standard for the identification of acute appendicitis is polymorphonuclear leukocytic infiltration of the muscularis region (74). Frequently, neutrophils and ulcerations are also existing within the mucosa. The diverse phases of appendicitis are frequently denoted as phlegmonous, gangrenous or perforated appendicitis. Still, the histopathological inspection has been identified to be an “defective gold standard” (33), as the criteria for the diagnosis of appendicitis are not determined and might differ between different foundations and explainers.

Histopathological examination displays neutrophilic infiltration in the submucosal layer and muscularis propria. Transmural inflammation with parts of necrosis and widespread mucosal ulcerations are perceived in histopathological examination of gangrenous appendicitis (59). Fig. (2.8).

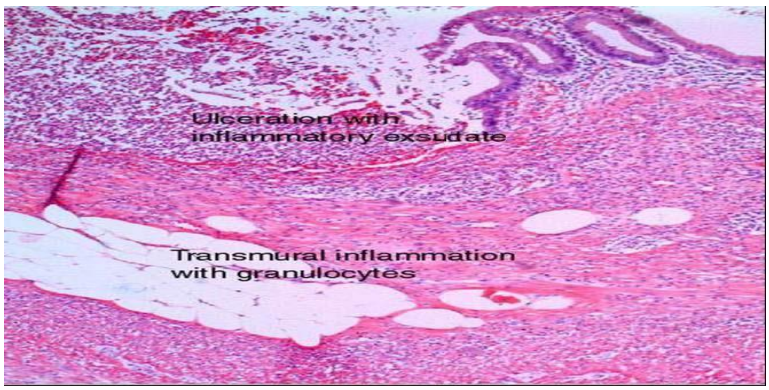

Fig. 2.8: Histological section of an acute appendicitis with ulceration of the mucosa and intense inflammatory infiltration of neutrophile granulocytes through the appendiceal wall.

2.13 Outcome of acute appendicitis and appendectomy

2.13.1 Mortality:

Nowadays, death after appendectomy is infrequent. The described mortalities differ therefore: 0.07% in one report from Germany (71), 0.23-0.24% in reports from Sweden (72). The probability of mortality post appendectomy is associated with the patients' age, comorbid diseases, and case severity. There appears to be higher mortality post negative appendectomy (7,72). The most common reasons behind deaths post appendectomies are cardiovascular illnesses (46%), appendicitis (18%), and other infections (14%) (118). An analysis from Finland described that open appendectomy had a six-fold increase in mortality compared to that of laparoscopic appendectomy. The study also displayed that overall mortality post appendectomy lessened in Finland, and this was probably as a result of more precise diagnostics and a higher percentage of laparoscopic appendectomies (114).

2.13.2 Morbidity:

The possibility of complications post appendectomy is associated with other the disease and the severity of appendicitis. Targeting better expectation and avoidance of

postoperative problems, researchers have established disease severity ordering systems according to intraoperative appearance of the appendix and the peritoneal space (119). Nevertheless, one research concluded that there were no alterations in the frequency or severity of complications post laparoscopic appendectomy for inflamed or non-inflamed appendix (120).

Laparoscopic appendectomy was presented to lead to less complications compared to open surgery (29). A Finnish study utilized information gotten from the Patient Insurance Association, and concluded that complications post appendectomy that cause a patient insurance claim were infrequent (0.2%). The frequency of paid claims post open and laparoscopic surgery were the same, but the compensated complications connected to laparoscopy were worse. just 57% of subjects that received payment had an appendicitis (114).

CHAPTER THREE

METHODOLOGY

3. Methodology

3.1 Study Design

A retrospective Observational Design will be used for this thesis to determine the relationship between the US, abdominal CT reports and Histopathology reports for patients who diagnosis with appendicitis after appendectomy surgery.

3.2 Study setting

The studies presented in this thesis were conducted in three hospitals in Palestine. Al-Makassed Islamic Charitable hospital is one of biggest NGOS hospital in east Jerusalem, and BeitJala Governmental hospital is one of biggest governmental hospital in west bank, and Alisteshari is a private hospital in west bank.

This study was performed in Radiology, Surgery and pathological departments at Al-Makassed hospital, BeitJala hospital, and Alisteshari hospital.

3.3 Target population

The target population of this study are all the patient who were clinically suspected of having acute appendicitis and were admitted to the surgery department of Al Makassed, BeitJala, and Alisteshari Hospitals who underwent appendectomy surgery.

The study was performed during a period of 3years and 8 months, from January 2016 to September 2019 at Al-Makassed and BeitJala hospitals, and during 1 year, from September 2018 to September 2019 at Alisteshari hospital. The study has been approved by the administration departments at all hospitals.

3.4 Sample

We retrospectively reviewed the medical records of the 476 patients who underwent appendectomy, including 257 males and 219 females.

3.5 Inclusive criteria

All patients who underwent appendectomy and received histopathology report and US and/or Abdominal CT reports.

3.6 Exclusive criteria

Any patients who underwent appendectomy without received any histopathology report or at least one radiological report.

The diagnostic performance of MRI was excluded from further analysis because of the small number of patients imaged by MRI. The study exclusive sample was 316 patients.

3.7 Data collection

All patients admitted to surgery departments because of clinically suspected appendicitis who underwent appendectomy were enrolled in the study.

Hospital ID of all patients who underwent appendectomy were extracted from IT department of all hospital and then Histopathology, and radiology reports were collected through the Hospital Information System HIS.

3.8 Data analysis

Statistical analysis was performed using SPSS® versions 23 (IBM, Armonk, New York, USA).

3.9 Timetable

This study was conducted retrospectively and the result was available by September 2019.

3.10 Budget

The research did not receive any grants.

CHAPTER FOUR

RESULTS

4. Results

The data of 792 patients who underwent appendectomy was analyzed, from which 316 patients were excluded from the statistical analysis because of absence of histopathogical or radiological reports (182 no radiological data, 134 no pathological data). From the 182 patients who had absent radiological data, 13 patients had negative appendectomy.

The remaining data of 476 patients was studied and analyzed.

The data of the 476 studied cases was collected from three hospitals. Table (4.1). Of the patients, 405 patients (85%) received just an ultrasound report, 15 patients (3%) received just a CT report with no ultrasound exam, and 56 patients (12%) received both US and CT reports.

The study included 275 male patients (54%) and 219 female patients (46%).

Table 4.1: Hospitals from which data was collected

Hospital	**Patient number**
BeitJala	261
Almakassed	190
Alisteshari	25
Total	**476**

Thirty-nine percent of studied patients (n=186) were pediatrics (<16years).

Results of pathology, US, and CT per hospital are presented in Table (4.2).

Table 4.2: Results of pathology, US, and CT per hospital

Hospitals	**Pathology**		**US**			**CT**	
	Positive	**Negative**	**Positive**	**Negative**	**Equivocal**	**Positive**	**Negative**
Governmental	242	19	152	32	77	25	3
NGOs	154	36	118	9	58	28	7
Private	10	15	11	6	7	4	1

4.1 Diagnostic performance of US

Of the 461 patients who were studied by US examination as a sole exam, or as a part of multiple radiological exam, the US showed inflamed appendicitis in 274 (59%), and showed a normal appendix in 46 (10%) while the US operator could not detect appendix in 141 (31%).

The result was positive in both of the pathology report and US in 80.6 percent of the cases that performed the two procedures (excluding equivocal results). The relationship between the result of the pathology report and US is shown in Table (4.3).

Table 4.3: Relationship between the result of the pathology report and US.

			US		Total
			NEGATIVE	POSITIVE	
PATHOLOGY	NEGATIVE	Count	13	16	29
		% of Total	4.1%	5.0%	9.1%
	POSITIVE	Count	33	258	291
		% of Total	10.3%	80.6%	90.9%
Total		**Count**	**46**	**274**	**320**
		% of Total	**14.4%**	**85.6%**	**100.0%**

There was a statistically significant difference between US result and the pathology results ($p<0.05$, Chi-square test)

The US showed an overall sensitivity of 89% and a specificity of 45%.

4.2 Diagnostic performance of CT

Seventy-one patients underwent CT scan (15 CT alone, 56 CT plus US). The CT showed an overall sensitivity of 91% and a specificity of 71%.

The result was positive in both of the pathology report and CT in 73.2 percent of the cases that performed the two procedures. The relationship between the result of the pathology report and CT is shown in Table (4.4).

Table 4.4: Relationship between the result of the pathology report and CT.

			CT		Total
			NEGATIVE	POSITIVE	
PATHOLOGY	NEGATIVE	Count	10	4	14
		% of Total	14.1%	5.6%	19.7%
	POSITIVE	Count	5	52	57
		% of Total	7.0%	73.2%	80.3%
Total		**Count**	**15**	**56**	**71**
		% of Total	**21.1%**	**78.9%**	**100.0%**

There was a statistically significant relation between CT result in correlation with Pathological results. ($p<0.05$, Chi-square test)

4.3 Correlation between US and CT

A total of 56 patients received both US and CT as a radiological modality for examination. Ten patients (18%) demonstrated a normal appendix on histopathogical exam (Group 1) and 46 patients (82%) demonstrate inflamed appendix on histopathology (Group 2) Table (4.5).

Table 4.5: Distribution of patients that received US, CT and pathology reports.

PATHOLOGY				CT		Total
				NEGATIVE	POSITIVE	
NEGATIVE GROUP 1	US	EQUIVOCAL	Count	4	4	8
			% of Total	40.0%	40.0%	80.0%
		NEGATIVE	Count	2	0	2
			% of Total	20.0%	0.0%	20.0%
	Total		**Count**	**6**	**4**	**10**
			% of Total	**60.0%**	**40.0%**	**100.0%**
POSITIVE GROUP 2	US	EQUIVOCAL	Count	1	20	21
			% of Total	2.2%	43.5%	45.7%
		NEGATIVE	Count	1	6	7
			% of Total	2.2%	13.0%	15.2%
		POSITIVE	Count	0	18	18
			% of Total	0.0%	39.1%	39.1%
	Total		**Count**	**2**	**44**	**46**
			% of Total	**4.3%**	**95.7%**	**100.0%**

US did not show any inflamed appendix in Group 1, it showed 8 non-detectable and 2 non-inflamed appendices. CT demonstrated 6 non-inflamed and 4 inflamed appendices (despite normal appendix on pathology).

In Group 1, both US and CT demonstrated normal appendix in 2 patients. However, CT demonstrated inflamed appendix in 4 cases which were non-detectable on US. CT demonstrated normal appendix in the cases which were non-detectable on US (n=4).

A total of 46 patients had both US and CT scan with an inflamed appendix on pathology. Twenty-one patients demonstrated a non-detectable appendix on US, 7 demonstrated negative US (despite being inflamed on pathology) and 18 patients demonstrated inflamed appendix.

CT showed inflamed appendix in 44 of the cases and only 2 non-inflamed appendices. CT and US demonstrated inflamed appendix in 18 patients and non-inflamed appendix in 1 patient on both US and CT.

There was a controversial result between US and CT in 27 patients as follows:

- Positive CT and equivocal US: 20
- Negative CT and equivocal US: 1
- Positive CT and negative US: 6

CHAPTER FIVE

DISCUSSION

5. Discussion

Acute abdominal pain is the most common case among emergency department patients. One of the most common pathologies is diagnosed behind acute abdominal pain is acute appendicitis (1). Despite its common occurrence, accurate diagnosis remains challenging.

Diagnostic imaging of appendicitis with graded-compression US and helical CT has steadily improved over the past decades, but the effect of radiologic imaging on negative appendectomy rates, perforation rates and management outcome has been a subject of discussion (7).

The ideal diagnostic test should be safe, fast, non-invasive, highly accurate, inexpensive and readily available. Several studies have demonstrated that higher sensitivity can be achieved when using helical CT compared to US, and it has been recommended as the method of first choice by several authors (28). During recent years, however, concern over the risks of ionizing radiation generated by CT has increased, especially in the pediatric population (94)

The results of our retrospective study demonstrate that both US and CT are excellent tools for making the diagnosis of appendicitis.

Radiologic imaging may guide whether a patient should be discharged home, admitted for observation, or given surgical treatment, which may lead to beneficial changes in management plans.

5.1 Ultrasonography

US is a generally available, relatively inexpensive and safe procedure that does not involve the use of ionizing radiation, and requires no patient preparation, although it is well known that US is highly operator-dependent. The major disadvantage of US is the fact that a negative US examination does not exclude appendicitis unless a normal appendix is confidently visualized.

Visualization rates vary widely in the published literature from 22 to 98% (88).

Our study demonstrated that from 461 patients who underwent US the visualization rate was 69.5% (320 from 461). Of those only 46 patients (14.4%) demonstrated normal appendix on US.

Appendicitis was not ruled out nor confirmed due to non-visualization in 141 patients, which necessitated another imaging modality (for example, CT) to be done, or to move directly to surgery if there was high suspicion.

Patient dependent difficulties include body constitution and meteorism.

In this study, the US showed a sensitivity and specificity of 89% and 45% respectively.

The result was in harmony with Skaane et. al (87) which resulted in a sensitivity range of 75-95% but was different from Garcia Pena et. al in which the specificity range was 90-95% (88).

In summary, US is a first-line imaging modality that can be used to identify which patients can go directly to surgery or when further imaging with CT is necessary.

5.2 Computed Tomography

This study shows that CT has 91% and 71% sensitivity and specificity respectively.

The result shows a low specificity rate in contrast to high specificity (91%-99%) in Sivit et. al (4). This may be due to poor protocol of CT examination in cases of suspected appendicitis. Further studies are advised to assess the cause of this poor specificity and to suggest solution to improve it, which is beyond the scope of this study.

CT should be added to the imaging protocol for patients who have negative US findings but clinical presentations are strongly suggestive of appendicitis, in inconclusive cases, or when the radiologist lacks experience with US.

Communication between the radiologist and the clinician is crucial for avoiding unnecessary CT studies (especially repeated examinations) and provides the greatest possible potential to minimize unnecessary ionizing radiation.

5.3 Correlation between US and CT

The main subject of this study was to correlate the result of the US and CT in diagnosis of cases of suspected appendicitis.

Only 56 patients underwent both US and CT scan. According to pathology reports, they were classified as group 1, which consisted of 10 patients (negative appendix) and group 2, which consisted of 46 patients (positive result, appendicitis).

In Group 1, both procedures showed matching results with pathology in 2 patients (20%). When the two procedures showed controversial results, CT appeared to have a high false positive results (CT showed inflamed appendix in 4 cases (40%)). However, US in this group did not visualize the appendix to rule out the diagnosis in 8 cases with a non-visualization rate of 80%.

In Group 2, both modalities showed matching results with pathology in 18 patients (40%) while 60% was unmatched. In the unmatched cases, CT appears to have a high true positive results of 96% (26 from the 27 patients).

US demonstrated high false negative with a rate of 15.2% and non-visualization rate of 45.7%.

However, in one case, CT had a result controversial to the pathology report and the US did not detect an appendix (both demonstrate false negative).

In conclusion, in cases with negative appendectomy, CT demonstrated high false positive results with 40% of all cases and true negative in 60% of the cases. In both situation US failed to visualize the appendix with a non-visualization rate of 80%.

However, in cases with approved appendicitis, CT showed high true positive rate of 96%, while US demonstrated high non-visualization rate of 45.7% and false negative in 15.2% of the cases.

The results show that CT had higher correlation with pathology results when the pathology demonstrated inflamed appendix, especially in cases not visualized by US. This suggests that the patient should be referred to CT when US is non-conclusive.

The study shows a limited value of CT in cases of non-visualized appendix on US and negative pathology with false positive of 50% of non-visualized appendix on US. These limited values do not go in harmony with other studies in literature.

Conclusion

When the pathology report was positive for appendicitis, CT had a higher correlation rate over US which had a very low specificity rate of around 45%. However, in negative pathology reports, CT had a 40% false positive rate.

Limitations

- A very high number of patients had missing data (either missing radiology report or missing pathology report).
- The sample from Al-Isteshari Hospital was smaller than the other two hospitals.

Recommendations

- Using US as the primary imaging modality in the evaluation of suspected appendicitis.
- Abdominal CT should be added to the imaging protocol when the US study fails to visualize the appendix but the patient has a clinical presentation strongly suggestive of, but not totally convincing for appendicitis, when the US study is inconclusive, or when the radiologist lacks experience with US.
- Improve CT protocols and improve knowledge of radiologists in diagnosis of appendicitis on CT.
- Increase the number of available radiologists and radiology services.
- Application of a standard protocol for diagnosis of appendicitis that should include oral and IV contrast media, using only one series (portal phase), and thin slice sections.

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Appendix A

جامعة القدس
كلية المهن الصحية
دائرة التصوير الطبي
القدس – أبو ديس

uds University
lty of Health Professions
al Imaging Dep.
lem - Abu Dies

28/07/2018

حضرة الدكتور بسام ابو لبدة المحترم\ مدير عام مستشفى المقاصد - القدس

تحية طيبة وبعد،

الموضوع :تسهيل مهمة باحث

ارجو العلم بان الطالب احمد عبد الرحمن محمد حسين طالب دراسات عليا في برنامج ماجستير تكنولوجيا التصوير الطبي \ مسار التصوير الطبي الوظيفي
(MSc Medical Imaging Technology – Functional Imaging track) في دائرة التصوير الطبي/ جامعة القدس.

يقوم الطالب احمد حسين بعمل بحث بعنوان القيمة التنبؤية للتصوير المقطعي والتصوير بالموجات فوق الصوتية في الكشف عن التهاب الزائدة الدودية
Predictive value of Computed Tomography and Ultrasonography in the detection of appendicitis).

حيث سيقوم الطالب احمد بجمع البيانات من مستشفى بيت جالا الحكومي ومستشفى المقاصد في القدس .

وعليه أرجو من حضرتكم التكرم بالايعاز للمعنيين بتسهيل مهمته.

وتفضلوا بقبول الاحترام والتقدير

د. محمد حجوج
منسق برنامج الماجستير

Makassed Islamic Hospital
RECEIVED
Date: 15.7.2019
Number: 776

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تلفون: 02 2791243 -+ 02 2799753 +
البريد الإلكتروني:
E-Mail:
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Appendix B

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State of Palestine
Ministry of Health
General Directorate
of Paramedical Services

دولة فلسطين
وزارة الصحـــــة
الإدارة العامة
للخدمات الطبية المساندة

الاخ الدكتور حمدي النابلسي المحتـــــــرم
ق.أ مـــــدير عام الادارة العامة للمستشفيات

القدس
al QUDS

الموضوع: تسهيل مهمة

تحية طيبة وبعد...

نرجو تسهيل مهمة الطالب احمد عبد الرحمن حسين – ماجستير تكنولوجيا التصوير الطبي من جامعة القدس لعمل بحث بعنوان القيمة التنبؤية للتصوير المقطعي والتصوير بالموجات فوق الصوتية في الكشف عن التهاب الزائدة الدودية لذا يرجى تسهيل مهمته في مستشفى بيت جالا الحكومي، مع العلم بأنه سيتم التعامل مع كافة المعلومات بسرية تامة وتستخدم لأغراض البحث العلمي فقط.

وتفضلوا بقبول فائق الاحترام،،،

أخوكم
نائبة النجار
مدير عـــــام
الإدارة العامة للخدمات الطبية المساندة

دولة فلسطين
وزارة الصحة
الإدارة العامة للمستشفيات

Ministry of Health – Ramallah
Ministry of Health - Nablus

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وزارة الصحة – رام الله
وزارة الصحة – نابلس

23. JUL. 2019 11:49 NO. 792

Appendix C

Al Quds University
Faculty of Health Professions
Department of Medical Imaging
Jerusalem –Abu Dis

جامعة القدس
كلية المهن الصحية
دائرة التصوير الطبي
القدس – أبو ديس

2019\09\08

حضرة الدكتور سعيد السراحنة المحترم \ مدير مستشفى االاستشاري العربي \ رام الله

تحية طيبة وبعد،

الموضوع :تسهيل مهمة باحث

ارجو العلم بان الطالب احمد عبد الرحمن محمد حسين طالب دراسات عليا في برنامج ماجستير تكنولوجيا التصوير الطبي \ مسار التصوير الطبي الوظيفي
(MSc Medical Imaging Technology – Functional Imaging track) في دائرة التصوير الطبي/ جامعة القدس.

يقوم الطالب احمد حسين بعمل بحث بعنوان القيمة التنبؤية للتصوير المقطعي والتصوير بالموجات فوق الصوتية في الكشف عن التهاب الزائدة الدودية
Predictive value of Computed Tomography and Ultrasonography in the detection of appendicitis).

حيث سيقوم الطالب احمد بجمع البيانات بعينة ممثلة للنظام الصحي الفلسطيني بمختلف القطاعات (الحكومي والأهلي والخاص).

وعليه أرجو من حضرتكم التكرم بالايعاز للمعنيين بتسهيل مهمته.

وتفضلوا بقبول الاحترام والتقدير

د. محمد حجوج
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