Improving the assessment process for patients presenting with acute (non-traumatic) abdominal pain to the general surgery department.

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Abstract

Background Abdominal pain is a very common but also challenging presentation to general surgery. A number of implementations have been introduced to improve the diagnostic process. These include: ED 4-6 hour targets, acute surgical admission units and better access to additional imaging (mainly CT scan). Regardless of these implementations, there seems to be ongoing inefficiency within the diagnostic process, with subjective observation of long transit times between presentation and start of treatment. Improving the diagnostic process and the use of imaging for this patient group will result in better use of hospital resources and improved patient care.

Section 1

Aim To evaluate the current process of how patients presenting with abdominal pain to the general surgery department are assessed.

Methods This section consists of 4 separate studies evaluating the number of admissions, diagnoses, the use of imaging and access to theatre.

Conclusion Over the last decade a significant increase was seen in the number of patients admitted with a non-surgical diagnosis (constipation, gastro-enteritis and non-specific abdominal pain). Also, CT scans were performed more frequently. This did, however, not affect the negative appendicectomy rate. Furthermore, according to an expert panel, approximately one-fifth of the scans was considered not indicated. These findings highlighted the areas for improvement in the diagnostic process for patients presenting with acute abdominal pain.

Section 2

Aim To identify the current evidence of diagnostic pathways for patients presenting acutely with abdominal pain.

Methods A systematic review was performed including all studies that described an algorithm for assessing patients presenting with acute, non-traumatic, abdominal pain

Conclusion The systematic review found that 10 studies described a diagnostic pathway for diagnosing patients with abdominal pain. All pathways supported routine imaging (ultrasound and/or CT scan). However, none of the studies reported a reduction in complication rate, mortality or length of stay.

Section 3

Aim The first step in this section was to identify whether registrars could accurately identify the urgent from the non-urgent patient presenting with abdominal pain. The second step was the implementation of a quality improvement initiative aiming to encourage early discharge for patients presenting with non-surgical abdominal pain and to reduce use of imaging for this patient group.

Methods This section contains of two prospective cohort studies.

Conclusion The first step showed that registrars could accurately identify the urgent from the non-urgent patient presenting with abdominal pain. This enabled us to introduce the second step, which was the implementation of a quality improvement initiative. In this study a significant increase in early discharges for patients presenting with non-surgical abdominal pain was observed and the use of imaging for this patient group significantly decreased. Representation and complication rates remained unchanged.

Overall conclusions This PhD highlights the problems in the assessment process for patients presenting with abdominal pain. When the assessment process can be optimised by implementing the quality improvement initiative, limited health care resources are used more wisely. This has obvious cost implications, but should also result in increased focus on patients with acute surgical pathology and improve their outcomes.

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List of publications

Acute abdominal pain- Changes in the way we assess it over a decade.

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doi: 10.1093/intqhc/mzy079.

How accurate is our early differentiation between the urgent and non-urgent patient presenting with acute abdominal pain?

K J de Burlet, A B M Lam, S J Harper, P D Larsen, E R Dennett

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List of abbreviations

AAA   Abdominal aortic aneurysm

ASU   Acute Surgical Unit

ATLS   Advances Trauma Life Support

CRP   C-reactive protein

CCDHB   Capital and Coast District Health Board

CCrISP   Care of the Critically Ill Surgical Patient

CT scan   Computed tomography scan

DHB   District Health Board

ED   Emergency department

EPA   The European Pathways Association

GI   Gastrointestinal

GP   General Practitioner

HDU   High Dependency Unit

IBD   Inflammatory bowel disease

ICU   Intensive Care Unit

IQR   Interquartile range

IUC   Indwelling urinary catheter

KPI   Key performance indicators

LOS   Length of stay

MINORS   Methodological Index for Non-Randomized Studies

NAR   Negative appendicectomy rate

NHS   National Healthcare System (UK)

NSAP   Non-specific abdominal pain

NSD	Non-surgical diagnosis
PID	Pelvic inflammatory disease
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
RACS	Royal Australasian Collage of Surgeons
RCS	Royal College of Surgeons (UK)
SD	Standard deviation
UK	United Kingdom
US	Ultrasound scan
UTI	Urinary tract infection
WCC	White Cell Count

Chapter 1: Introduction

1.1 Definition

Abdominal pain refers to a discomfort or pain sensation in the abdominal region. The pain can originate from within the abdomen itself, it can be from a musculoskeletal origin or referred from the chest, groin or back. It is a very common complaint, with causes ranging from mild and self-limiting to life threatening conditions. It can be acute (where the pain started within the last hours or days), traumatic (where the pain is a consequence from a recent traumatic event) or chronic (where the pain is longstanding or when patients have recurrent flare-ups of the same pain). When patients seek medical expertise because of the pain, they may present to their general practitioner (GP) or to the emergency department (ED), from where they can be referred onwards to multiple specialties within the healthcare system, including, but not limited to; gynaecologists, gastro-enterologists, general surgeons, urologists, vascular surgeons, orthopaedic surgeons and general physicians.

Abdominal pain is a common reason to seek medical care. A recent meta-analysis ranked it ninth place on the list of most common presentations in a general practice and that represents a consultation prevalence of approximately 2.8%(1), while it represents between 5-10% of all ED presentations(2-4). Approximately 25% of the patients presenting to ED with acute abdominal pain require an admission, which is most commonly to a general surgery department(3).

About two third of the patients who present to ED with abdominal pain are female and the average age is forty, both of these characteristics have remained unchanged over the last decades(3).

1.2 Aetiology

Causes of abdominal pain can either be divided per anatomic system or tract involved, by location of the pain, by urgent versus non-urgent conditions,

female versus male patients, the elderly versus the younger patient and lastly the patient presenting with non-specific abdominal pain (NSAP).

Differentiation per anatomic system and tract

The gastro-intestinal (GI) tract is often further divided between upper and lower GI tract. This is the most common tract involved. Pain is generally caused by inflammatory or obstructive pathologies. The most common aetiologies are(1, 3):

- Gastro-enteritis (7.2–18.7%)
- Irritable bowel syndrome (IBS) (2.6–13.2%)
- Gastritis (5.2%)
- Biliary/pancreatic (4.0%)
- Diverticulitis (3.0%)
- Appendicitis (1.9%)
- Neoplastic diseases (1.0%)

The urogenital tract is the second most common tract involved (5.3%), with a urinary tract infections (UTI) being the most frequent diagnosis causing pain. Other common causes include: renal calculi, testicular torsion and pyelonephritis.

The female reproductive tract is also a common source of mainly lower abdominal or pelvic pain. Causes of abdominal pain can be further subdivided into:

- Inflammatory: e.g. pelvic inflammatory disease (PID)
- Mechanical: e.g. ovarian torsion
- Endocrinological: e.g. menstruation, Mittelschmerz (ovulation pain)
- Tumours (benign and malignant): e.g. endometriosis, fibroids, ovarian cyst, ovarian cancer
- Pregnancy: e.g. ruptured ectopic pregnancy, threatened abortion/early delivery, pregnancy complication including (pre-) eclampsia, placental pathologies, etc.

Musculoskeletal pain is more common in younger patients and after trauma or sport injuries. Causes can also include neurogenic pain (e.g. herpes zoster, radiculitis in Lyme disease, abdominal cutaneous nerve entrapment syndrome (ACNES), tabes dorsalis).

Abdominal pain originating from the circulatory tract is rare, but includes ischaemic pain, aortic dissection and ruptured aneurysm of the abdominal aorta (AAA). Ischaemic pain can be further differentiated between non-intestinal ischaemia (e.g. omental, epiploic, splenic or hepatic infarct) and intestinal ischaemia. Intestinal ischaemia can be secondary to atherosclerosis, arterial embolism, venous congestion and non-occlusive mesenteric ischemia. Non-occlusive mesenteric ischemia is thought to occur as a result of splanchnic hypoperfusion and vasoconstriction and most commonly affects the "watershed" areas of the colon that have limited collateralization, such as the splenic flexure and rectosigmoid junction

There are multiple other less frequently occurring causes of abdominal pain including; auto-immune disorders, metabolic diseases or intoxication.

Abdominal pain secondary to a trauma

The pain in this case is dependent on the trauma and distracting injuries. The most important differentiation is blunt versus penetrating trauma, where blunt trauma often has a greater impact on the patient than initially expected on examination. While distracting injuries can lead to missing an initially controlled intra-abdominal pathology. Therefore a structured approach for the trauma patient is essential, but this is beyond the scope of this thesis(5).

Differentiation based on the location of the pain

Another method of differentiating abdominal pain is by its location. This is often done by dividing the abdomen into 4 quadrants or 9 areas. The cause of the pain is then most likely from pathology in one of the underlying organs or structures.

Dividing the abdomen into 4 quadrants is done by drawing an imaginary line from xyphoid, through umbilicus to pubic tubercle and a horizontal line from the umbilicus (figure 1.1).
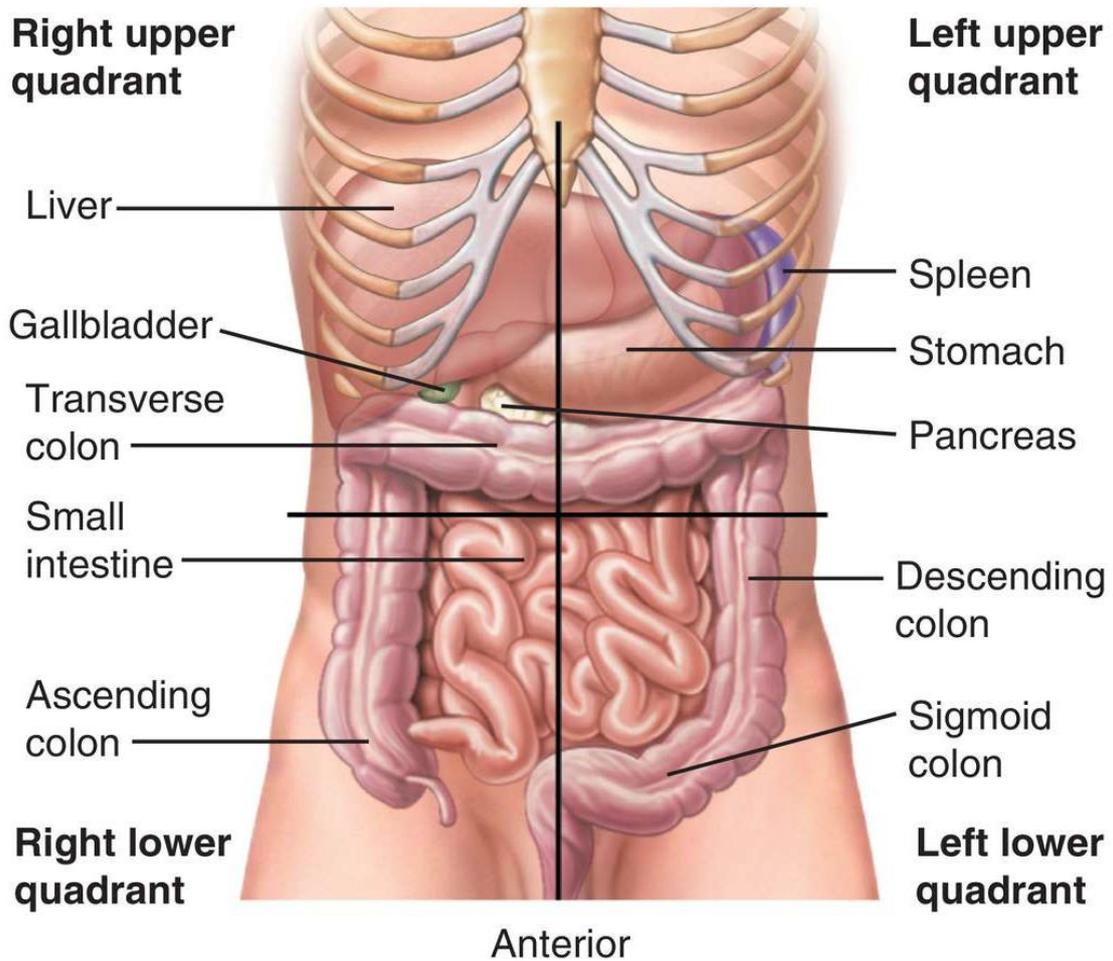
Figure 1.1 Abdominal organs divided into 4 quadrants. Permission to publish granted by Elsevier(6)

Dividing the abdomen into 9 areas or regions is more commonly practised. Two imaginary lines are drawn by extending the mid clavicular lines to the middle of the inguinal ligaments. Two horizontal lines are drawn from the subcostal margin on the left side to the right side and the other from the tip of the iliac crest on the left side to the rights side (figure 1.2).

Right Hypochondriac Region	Epigastric Region	Left Hypochondriac Region
· Liver · Gallbladder · Right kidney	· Stomach · Liver · Pancreas · Right and left kidneys	· Stomach · Liver (tip) · Left kidney · Spleen
Right Lumbar Region	**Umbilical Region**	**Left Lumbar Region**
· Liver (tip) · Small intestines · Ascending colon · Right kidney	· Stomach · Pancreas · Small intestines · Transverse colon	· Small intestines · Descending colon · Left kidney
Right Iliac Region	**Hypogastric Region**	**Left Iliac Region**
· Small intestines · Appendix · Cecum and ascending colon	· Small intestines · Sigmoid colon · Bladder	· Small intestines · Descending colon · Sigmoid colon

Figure 1.2 Dividing the abdominal cavity into 9 areas. Permission to publish granted by Nanoprom (7)

Although in theory this method of differentiating abdominal pain by location seems to be a broadly applicable and straight forward, there are several downsides. Pain from any aetiology may in some cases be poorly localised due to the nerve supply in the abdomen (referred pain).

The peritoneum consists of two layers which are continuous with each other; the parietal peritoneum and the visceral peritoneum. They both consist of one layer of simple squamous epithelial cells, called mesothelium. The parietal peritoneum lines the internal surface of the abdomino-pelvic wall. It is derived from somatic mesoderm in the embryo. It receives the same somatic nerve supply as the region of the abdominal wall that it lines, therefore pain from the parietal peritoneum is well localised and it is sensitive to pressure, pain, laceration and temperature. The visceral peritoneum covers the majority of the abdominal organs or viscera. It is derived from splanchnic mesoderm. The visceral peritoneum has the same nerve supply as the viscera it invests. Unlike the parietal peritoneum, pain from the visceral peritoneum is poorly localised and is only sensitive to stretch and chemical irritation. Pain from the visceral peritoneum is referred to areas of skin (dermatomes) which are supplied by the same sensory ganglia and spinal cord segments as the nerve fibres innervating

the viscera. The peritoneal cavity is the space between the parietal and visceral peritoneum. The retroperitoneal cavity is the space posterior to the visceral peritoneum (figure 1.3). Pain caused from pathologies in retroperitoneal organs (pancreas, kidneys, duodenum, aorta, etc.) are often therefore felt in the back.
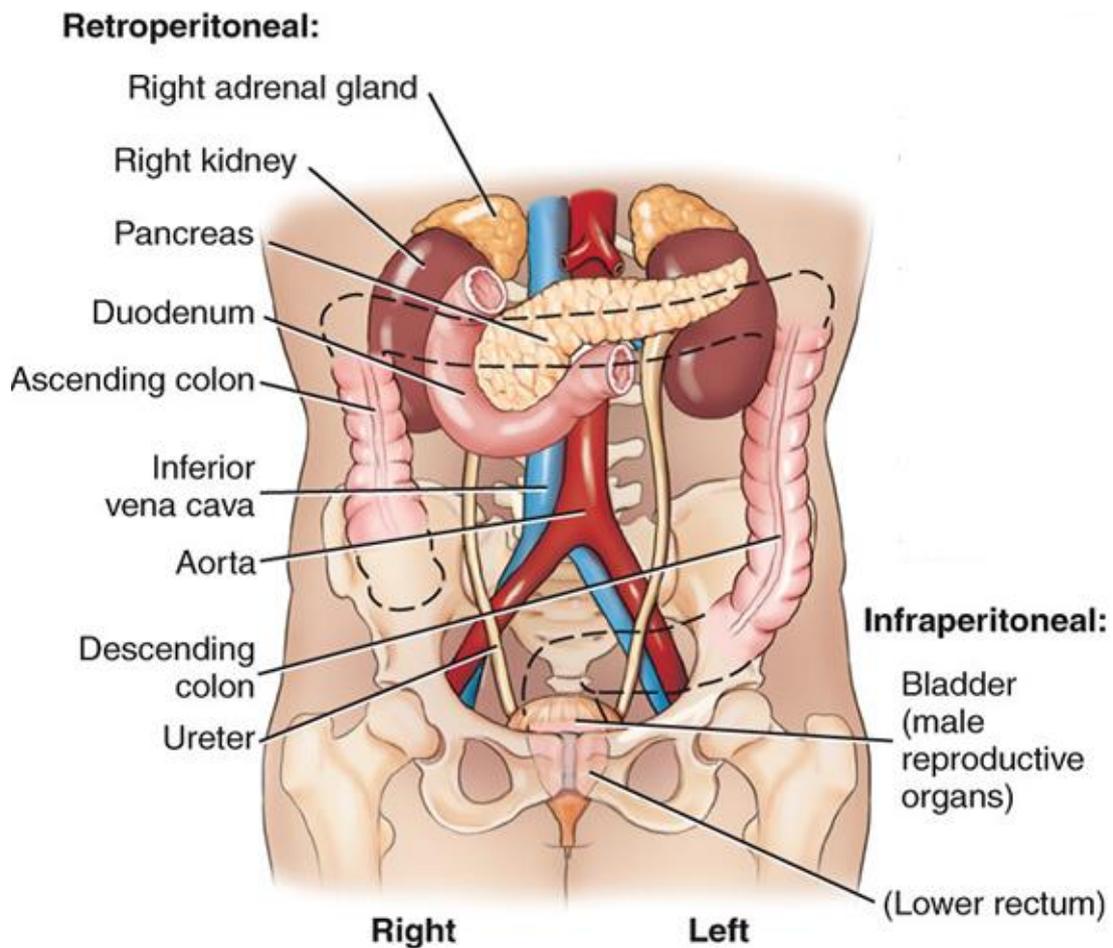
Figure 1.3. Retroperitoneal organs. Permission to publish image granted by Study Blue(8))

Differentiation based on urgent versus non-urgent presentations

About one in ten patients presenting with abdominal pain to the ED has an urgent diagnosis requiring acute intervention in the form of an operation, drainage of a collection, acute endoscopy or intensive care unit (ICU)

support(1). The most common diagnosis within this group is appendicitis, with over 5000 hospital admissions annually in New Zealand(9). Patients categorised as urgent need access to imaging and theatre promptly to treat their underlying condition and to reduce the risk of morbidity and mortality. While non-urgent patients may be treated conservatively or are better off with a planned operation or procedure as previous studies have shown that non-elective procedures are associated with a greater risk for associated morbidity and mortality compared to elective procedures(10). To date it is not clear whether we can accurately make the differentiation between urgent and non-urgent patients presenting with acute abdominal pain to the hospital.

Differentiation between female and male patients and pelvic pain

The majority (approximately 66%) of the patients presenting with abdominal pain to ED are female(3). Three major general population studies have estimated the total three months population prevalence for pelvic pain including both sexes at 14.7% in the United States(11), 24% in the United Kingdom(12) and 25.4% in New Zealand(13). Multiple specialties are involved in the treatment of pelvic pain. The GP is involved the most, but other specialties include: urologist, gynaecologist and general surgeon.

It is obvious that, due to the anatomical differences between males and females, abdominal or pelvic pain can present very differently. Pelvic pain has historically been a diagnostic challenge(14). In women, a gynaecologist is often the primary carer as pelvic pain is most commonly caused by endometriosis, with a worldwide prevalence of 6-10% with PID being the second most common cause(15, 16). While in men, the urologist is often involved as prostatitis is the most common cause for pelvic pain(17).

Not only is there a difference in pathology causing the pain, there are also multiple studies that have observed differences in pain sensation and responses to analgesia between the sexes(18-20). Research in this field is ongoing, further discussion about this goes beyond the scope of this thesis.

Differentiation between younger and elderly patients

Some diagnoses are more common in the younger patient presenting with abdominal pain, including appendicitis, gynaecological and urological pathologies. The diagnostic process of elderly patients can be more challenging (21).

A recent study from the United States of America showed that 15% of all ED presentations are patients 65 years and older(22). A study specifically evaluating the prevalence of abdominal pain in patients over the age of 75 noted that a total of 31% of the men and 42% of the women had experienced at least one episode of abdominal pain within the past year and among them 25% had visited a doctor for this pain(23). Also, compared with younger patients, this patient population has a significantly more complex medical and surgical history and are less likely to present with classic symptoms, physical examination findings, and laboratory values of abdominal diseases. This makes the diagnostic process challenging for this age group. Furthermore, length of stay (LOS) is significantly longer for elderly patients and associated morbidity and mortality risks are significantly higher compared to younger patients. The latter two appears to be multi-factorial; late and non-classic presentation, pre-existing comorbidities and frailty are all reasons given in studies to explain the poorer outcome in the elderly(21, 23, 24).

To conclude, the differential diagnosis of a patient presenting with abdominal pain is clearly dependent on the age and medical history of the patient(21).

Differences between ethnicities

ED use is different between ethnicities. In New Zealand, Pacific peoples have the highest rate of ED visits at 19.3 per 100 population per year, followed by Māori at 18.0 per 100 population per year whereas it is only 14.5 per 100 population per year for European and other ethnicities (25). Despite the differences in presentation rates a recent study showed that there was no

difference in length of ED stay and another study found no differences in the incidence of chronic pain between ethnicities(26, 27).

Non-specific abdominal pain

The cause for the pain cannot always be identified, so called NSAP, and this is the case in about a third of the patients presenting with abdominal pain to the GP and about 25% for patients presenting to ED(1, 3, 28). The incidence of NSAP in ED has dropped over the last few years and this is most likely a consequence of increased use of additional diagnostic tests. About 90% of the patients who are discharged without a specific diagnosis for their abdominal pain, turn out to be pain free two to three weeks after their presentation(29). However, about 28% suffer from recurrent episodes of the same pain and require multiple additional tests (30) and 6% re-present to ED and require an operation for a diagnosis that was missed at their initial presentation(3).

1.3 Diagnostic process

As outlined, abdominal pain is a common problem and has major diagnostic challenges. Approaching a patient presenting with abdominal pain in any setting one should start by taking a thorough medical history and examination. In approximately 40-50% of the cases a correct diagnosis can be made from this alone(31, 32), although some older studies believe it to be as high as 80%(33, 34). More important than getting the correct diagnosis based on the history and examination is making a judgement about whether the patient is unwell and needs urgent treatment or whether the patient is well and can be discharged safely without further diagnostic tests or outpatient investigations (32).

Recognising and assessing urgent patients is taught to surgical registrars in the Care of the Critically Ill Surgical Patient (CCrISP ®) course by the Royal College of Surgeons (RCS) in the United Kingdom and the Royal Australasian College of Surgeon (RACS) in Australia and New Zealand. They have developed an algorithm (figure 1.4) that is applicable for assessing any surgical

patient on the ward or in the ED (35). The most important step of this algorithm is deciding whether you are dealing with a stable or an unstable patient. The 'end-of-the-bed-o-gram', patients vitals and clinical situation will determine whether you would place the patient in one group or the other and management is dependent on this assessment.
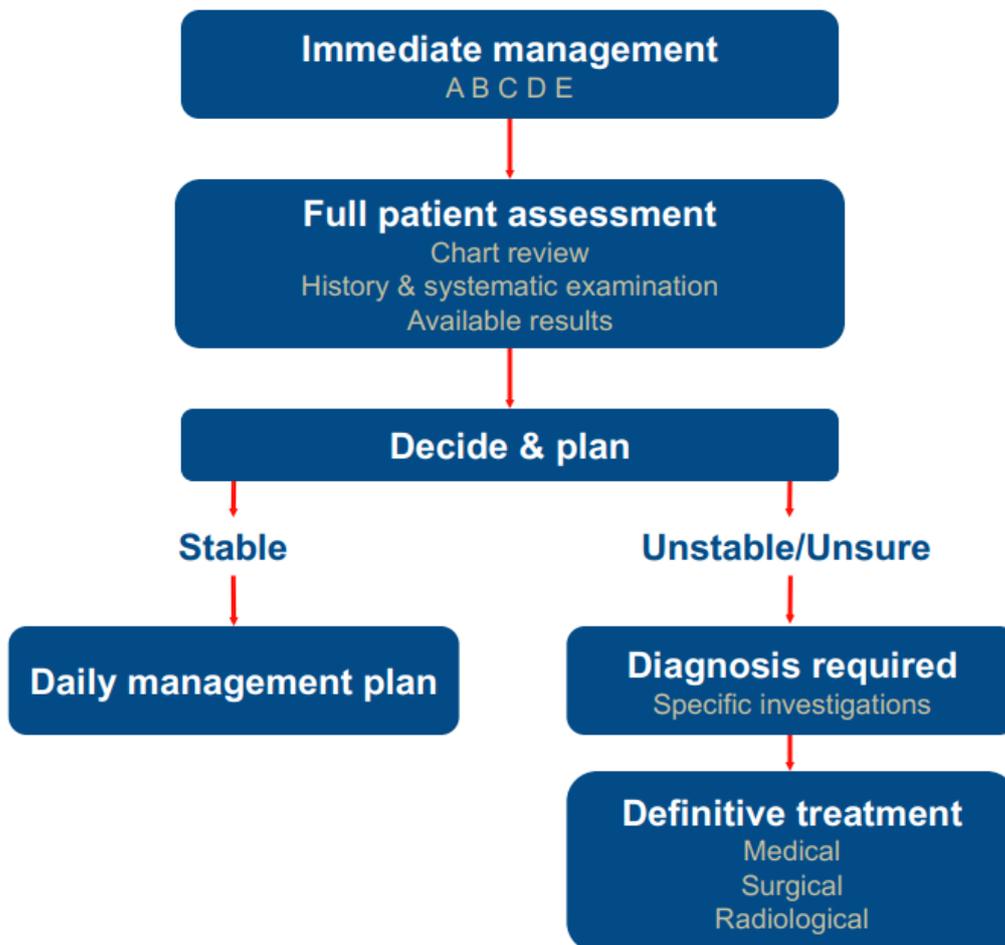
Figure 1.4 CCrISP® algorithm. Permission to publish image granted by RCS(35)).

The next step in the diagnostic process is often laboratory tests and a urine analysis. A urine analysis is helpful to assess for haematuria, evidence of UTI and pregnancy test. A pregnancy test should be performed in all women of childbearing age to rule out pregnancy as a cause of the pain.

Laboratory tests will be requested depending on the findings of the clinical history and abdominal examination. Inflammatory markers including white cell count (WCC) and C-reactive protein (CRP) are often used to differentiate urgent from non-urgent patients. However, in a large number of underlying conditions for acute abdominal pain (inflammatory and non-inflammatory conditions), the values of either of these can be elevated(36-38). A recent study including close to three-thousand patients concluded that neither CRP nor WCC are sufficient markers to be used as a triage test in the selection for diagnostic imaging or to differentiate urgent from non-urgent patients presenting with acute abdominal pain, even with a longer duration of complaints(36).

The role of plain films to aid diagnosis for patients presenting with acute abdominal pain is limited. However, they are easy to obtain and carry little risk to the patient. Therefore, they are still commonly used, especially in patients with a suspected foreign body, bowel obstruction or perforated viscus(39-42).

Additional use of imaging, in the form of ultrasound scans (US) or computed tomography (CT) scans, is increasingly common for this patient group. US avoids radiation exposure and is inexpensive, however, the availability depends per institution and so does the diagnostic accuracy. It is a dynamic real-time examination that makes use of postural variation and can be guided by the location of the pain. US exploration of the pelvic cavity in women may be supplemented by endo-vaginal ultrasound probes(39, 41).

Many studies emphasize the diagnostic accuracy of the CT scans and its impact on the management of abdominal emergencies. The use of this diagnostic tool has significantly increased over the last decades(37, 39, 41, 43, 44). Routine use of CT scans however is associated with increased patient radiation, waiting times and hospital costs(45, 46). A 'low dose' CT scan, where the effective radiation dose is reduced (1.2-4.2 mSv for low-dose CT scans vs

10–15 mSv for normal dose), has been suggested as solution to the radiation exposure. They have been shown to be non-inferior in diagnoses like appendicitis or diverticulitis(47, 48). Downsides are that diagnostic accuracy is reduced when a diagnosis is not that obvious and in patients with an increased body mass index (BMI), therefore this may result in repeat scanning and with that increased radiation exposure(41, 49). Overall, a selective approach for the use of CT scans for patients presenting with acute and non-traumatic abdominal pain may be warranted, but clinicians still struggle with determining who will actually benefit from the additional imaging and who will not(39, 46).

1.4 Diagnostic accuracy

Diagnostic pathways for assessing surgical patients have been around for centuries(50). At the end of the 1960's a group of British surgeons developed a computerised system that aided the junior registrar in making a correct diagnosis for a patient presenting with abdominal pain. While the diagnostic accuracy of the clinician alone was reported as being between 40 to 73%, this computerised system could lead to a diagnostic accuracy of 91.8%(51-54). This computer aided diagnostic process, however got out of fashion with the introduction of other diagnostic tools such as peritoneal lavage(55) and diagnostic laparoscopy (56, 57). In recent years, however, imaging (mainly CT scan) has replaced most of these diagnostic tools because of the well-established high accuracy (over 90%) and the low risks associated with it(39, 41, 43).

The same developments were seen in the United States. A study performed in 1972 showed that out of a 1000 patients presenting with acute abdominal pain to the ED 95.0% would have laboratory tests (full blood count (FBC)) and 42.7% would have an abdominal X-ray. In 41.3% no diagnosis was found that would explain the patient's symptoms, even though 12.0% were followed up in the outpatients department. In 8 cases (0.8%) a surgical diagnosis was missed. In total 27.4% of the patients were admitted to the hospital(58). This study was repeated in the same institution in 1992. This time they did laboratory tests in 56.9%, all of them had a FBC and two thirds had

liver function tests (LFT) as well. Plain X-rays were used less frequently (30.2%), but advanced imaging was used in 6.8% (0.8% CT scan, 6.0% US). This resulted in a significant decrease of patients diagnosed with NSAP (24.9%) and only one patient (0.1%) had a missed surgical diagnosis. In total 18.3% of the patients were admitted to the hospital. The authors explained that the reduction in the number of admissions is likely a consequence of the development of an improved ED department with ED specialists(4). Fifteen years later, they repeated the study again in the same institution. This time laboratory tests were used in 64.5% (all of them FBC and 84.3% LFT) and plain X-rays were used in 21.0%. The use of advanced imaging had increased 6-fold to 42.6% of the patients receiving either a CT scan or an US (25.6% CT scan and 20.9% US). In total 21.1% was diagnosed with NSAP and 2 patients (0.2%) had a missed surgical diagnosis. In total 24.8% of the patients were admitted to the hospital(3).

These three studies nicely show the development of the diagnostic process for patients presenting with abdominal pain over 35 years. They clearly show that the use of abdominal X-rays has decreased, while the use of CT and US has increased. As a consequence, less patients are diagnosed with NSAP (41.3% in 1972 vs 21.1% in 2007), however the number of missed diagnosis remained virtually unchanged (0.8% in 1972 vs 0.2% in 2007). Therefore the last study, summarising the results of the three cohorts, concluded that although diagnostic accuracy has improved with help of the additional imaging this was mainly reflected in an increase in the incidence of more specific benign diagnoses. The same study also showed that the average ED physician time expenditure for this patient group increased from an average of 2.9 hours in 1992 to 4.3 hours in 2007. Lastly, the initial decrease in hospitalisation seen between 1972 and 1992 (27.4% to 18.3%), reverted to an increase between 1992 and 2007 (24.8% in 2007). Overall, the authors concluded that increased diagnostic accuracy comes with an increased time expenditure, increased use of hospital resources and increased hospitalisation (between 1992 and 2007), while the number of missed diagnoses remains unchanged(3, 4, 58). Also to date, there is no evidence that this increase in diagnostic accuracy has resulted in a decrease in morbidity, mortality and length of stay(3, 44).

1.5 Implementations to improve patient flow

Worldwide multiple implementations have been introduced to improve the flow of the acute presenting patient through the hospital. The two most important ones for patients presenting to general surgery are the ED four or six hour target and the introduction of acute surgical units (ASU's).

Emergency department four or six hour targets

ED overcrowding remains an issue, defined as the 'situation where ED function is impeded primarily because the number of patients waiting to be seen, undergoing assessment and treatment or waiting for departure exceeds either the physical bed and/or staffing capacity of the ED(59, 60). The adverse consequences of overcrowding in ED's have been discussed extensively in the literature, demonstrating an association with significantly poorer patient outcomes(60-62). This led to the introduction of the four hour target by the National Health Service (NHS) in the UK in 2000(63). From that point on, 98% of all ED patients were to be assessed and either discharged home or admitted to a ward within four hours(63). Initial data from the UK were very promising, showing a significant reduction in ED length of stay, morbidity and mortality, without increasing the number of re-presentations(62, 64, 65). As a result, four and six hour targets were implemented around the world(66, 67). In May 2009, the Ministry of Health formally announced six national health targets for public hospitals in New Zealand and one of these was the six-hour target for patients presenting to ED(68-70). More recent publications of the effect of the four and six hour targets for not only ED, but also the admitting services have been a bit more sceptical as to the effects of the targets. A study from the UK found a gross increase in inpatient disposition within 20 min prior to the four hour target. They concluded that this was an unintended side effect of the target, and that ED's are performing to the targets, but this may not improve overall care(62). A study from Australia predicted that rushed care, decreased time for relevant investigations and inappropriate referrals are all possible consequences of a target-based approach to clinical decision-making(71). Two more recent studies from the same country found that since the introduction of the four hour target

there was an eightfold increase in inpatient transfer between treating teams within forty-eight hours of admission, suggesting that due to 'rushed referrals' patients were being admitted under the wrong in-hospital service(67). Furthermore, they found that the decrease in ED length of stay goes hand in hand with an increased burden on acute admission wards such as short stay units and acute medical or surgical units(69, 72).

Acute surgical Unit (ASU)

The traditional model of care for patients admitted with acute general surgical conditions has been an "on-call" system. The consultants would be on-call for emergencies while performing their routine daily work, which may be consulting or operating nearby or remote from the acute hospital service. The patients were admitted under their care and remained under the care and responsibility of the receiving surgeon throughout their admission. The emergency workload was seen as a necessary, unavoidable and unplanned burden. Surgical intervention, when necessary, was undertaken either on an elective list displacing booked cases or after hours on an acute list. This often resulted in increased pressure on elective work and waiting lists lengthened. This model has created difficulties in ongoing management of the acute general surgical workload in a number of hospitals internationally(73-75). The realisation that the old model did not achieve the standards of care for the patients presenting acutely to general surgery led to development of new care models worldwide. The new care models often include a dedicated on call roster for both registrars and consultants without elective duties, a special ward or part of a ward where nurses were trained to look after acute surgical patients, advanced imaging (US or CT) slots for the acute patients and an acute theatre list(76-79). Multiple studies have evaluated their 'new care model' and concluded that they have led to improved care (reduced length of stay and morbidity) for a patient presenting acutely to a general surgery department(76-79).

1.6 The clinical challenge

As outlined, abdominal pain is a challenging presentation to the ED. Laboratory tests, US and CT scans are helpful to improve the diagnostic accuracy. However, there appears to be a price attached to the improved diagnostic accuracy obtained with the additional imaging. Furthermore, the improved accuracy is mainly reflected in determining a specific, often benign, diagnosis (e.g. diverticulosis). This may not improve patient care and could ultimately be harmful due to radiation exposure and increased waiting times. A more selective approach should therefore reduce hospital waiting times, reduce hospital costs and optimally improve patient safety. How to solve this clinical challenge remains unclear. A diagnostic pathway might aid clinicians in making decisions about when to use imaging and when admission is required.

1.7 Wellington demographics and current situation in Wellington hospital

Population

The population in the Wellington region has increased by about 5% over the last decade and approximately 471,315 people live in the district(80). The three district health boards (DHB's) supplying health care for the region are; Wairarapa DHB in the Masterton, Hutt Valley DHB in Lower Hutt and Capital and Coast DHB (CCDHB) in Wellington city. The three DHB's work closely together and CCDHB provides tertiary services for the other two DHB's and for the lower half of New Zealand's North Island and upper part of the South Island.

Wellington region is a relatively young region compared to other regions, according to the national data of New Zealand(80), with a male to female ratio of 1/1.07 (figure 1.5). The median age is 37.2 years and for New Zealand as a whole it is 38.0 years. Only 13.2% of people in the Wellington Region are aged 65 years and over, 19.5% are youngers than 15 years compared with 14.3% and 20.4% respectively for all of New Zealand(80).
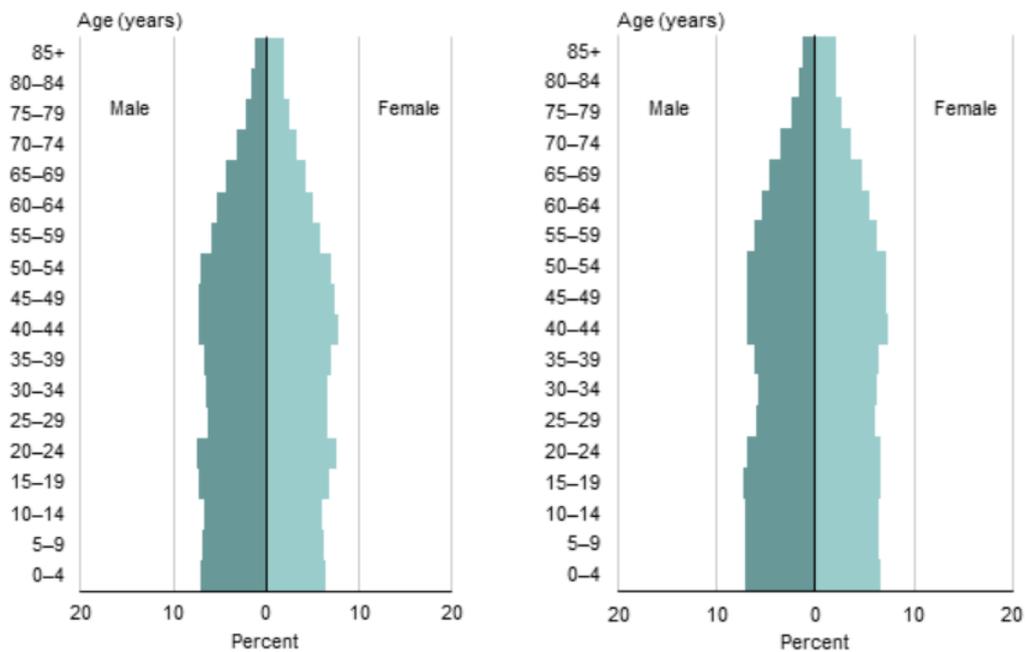
Figure 1.5 Percentage of men and women of various ages for the Wellington Region (left) and New Zealand (right) according to the 2013 census. Permission to publish image granted by Statistics NZ(80))

The majority of the population in the Wellington region are from a New Zealand/European background, 77.0% compared to 74.0% for the total New Zealand poulation. The region also has a slightly smaller Maori population compared to the whole of New Zealand, 13.0% vs 14.9% (table 1.1).

Table 1.1 Ethnic groups in Wellington region and New Zealand (2013)

	Wellington Region (%)	New Zealand (%)
Ethnic group		
European	77.0	74.0
Māori	13.0	14.9
Pacific peoples	8.0	7.4
Asian	10.5	11.8
Middle Eastern, Latin American, African	1.5	1.2
Other ethnicity nec	1.8	1.7
nec; not elsewhere classified(80)		

The Emergency Department (ED)

The six hour ED target was introduced in Wellington hospital together with the rest of the country in May 2009. Over the last years the number of ED presentations has increased steadily (figure 1.6). This is most likely due to easy accessibility and there being no charge for patients, compared to the appointment based service and fees of the GP.

Figure 1.6 Emergency department presentations in Wellington Hospital(81)
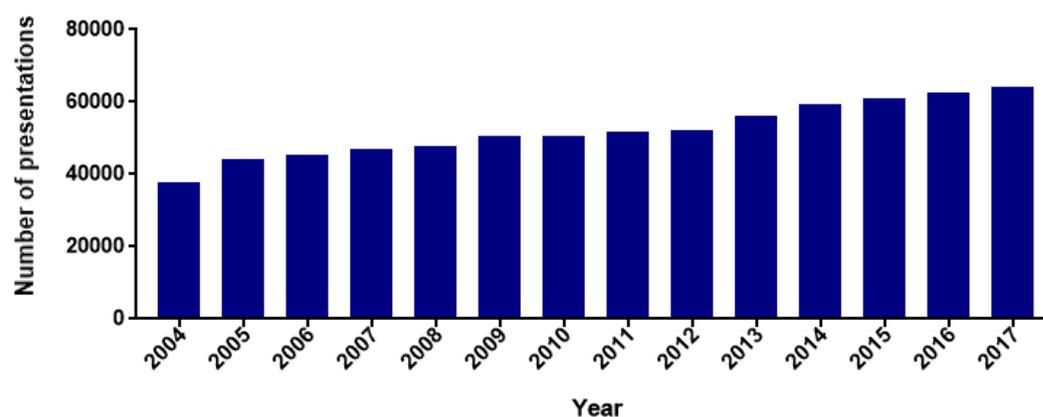
ED use was different between ethnicities. Pacific peoples had the highest age-standardised rate of ED use in 2014/15 (19.3 per 100 population), followed by the Māori (18.0 per 100 population), European or Other (14.5 per 100 population) and Asian (9.4 per 100 population) peoples. All ethnic groups showed an increase in the rate of ED use from 2010/11 to 2014/15(25).
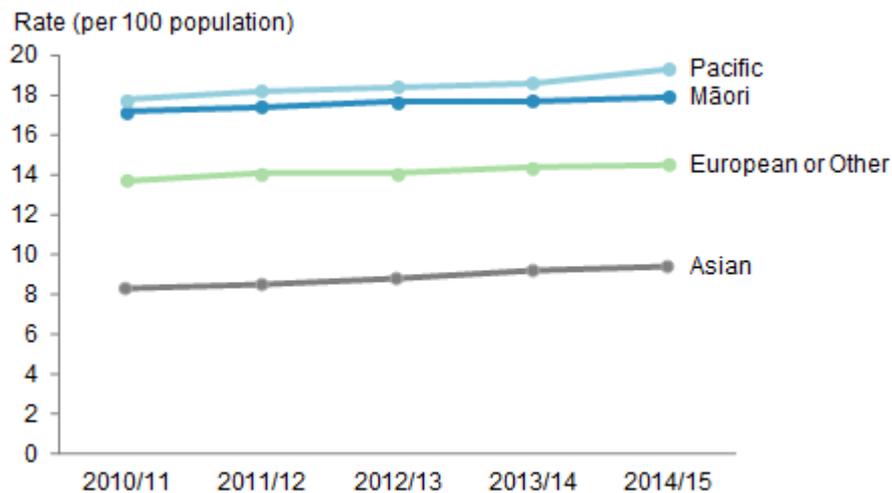
Figure 1.7 Rate of people who were patients at an emergency department at least once during the year, by ethnic group, 2010/11–2014/15.
Permission to publish image granted by the Ministry of Health(25)

Wellington ED is divided into a minor care zone containing eight cubicles, a major care area containing 21 beds and a resuscitation zone containing three beds. Triage of patients is done by specialised ED triage nurses. They assign a code to a patient based on the urgency to which they think the patient needs to be treated. Code 1 means that the patient has to be seen immediately, code 2 within 10 minutes, code 3 within 30 minutes, code 4 within 60 minutes and code 5 within 120 minutes(82).

Acute Surgical Unit (ASU) and supporting services

The general surgery department has an ASU, which was introduced in July 2013 and this is a consultant led service. During the week (Monday to

Thursday) there is one consultant on duty based in the hospital from 8am until 6pm. Between 6pm and 8am another consultant is on-call, they do not have to be in the hospital. In the weekends (Friday 8am to Monday 8am) there is one consultant, on duty from 8am to 6pm Friday then on-call until 8am Monday. Furthermore, there are two registrars assigned to deal with acute admissions from Monday to Friday 8am to 6pm. From 4pm there is an additional evening registrar until 11pm. During the weekends (Saturday and Sunday) there is one junior registrar on call from 8am until 4pm and one senior registrar from 8am until 11pm. There is a separate roster for nights with one registrar on-call from 11pm to 8am. Unlike the consultants the registrars on-call are always on-site. Senior registrars are defined as senior when they are enrolled in the Royal Australasian College of Surgeons (RACS) Surgical Education and Training Program in general surgery or when they have more than four years of post-graduate experience.

Handovers for the entire surgical department are every morning during the week. On Friday morning this is accompanied by a departmental morbidity and mortality meeting.

Patients present to the ASU when they are referred via ED or by their GP. Patients referred to general surgery from a different inpatient service will generally have been seen first on the ward of the referring service.   GP referrals still have to present to ED first where a triage nurse will determine whether the patient is fit for transfer to the ASU or needs resuscitation treatment in ED. The ED triage nurses base this decision on the early warning score (EWS), with a score lower than 3 a direct referral to the ASU is considered acceptable and is approved by both the emergency and the general surgery department (figure 1.8).

SCORE	MET	3	2	1	0	1	2	3	MET
ZONE	BLUE	RED	ORANGE	YELLOW	WHITE	YELLOW	ORANGE	RED	BLUE
Resp Rate	<5	5-8		9-11	12-20		21-24	25-35	>35
SpO₂		≤91	92-93	94-95	≥96				
Supplemental O₂			YES		NO				
Temp			<35.0	35.0-35.9	36.0-37.9	38.0-38.9	≥39.0		
Sys BP	<70	70-89	90-99	100-109	110-219		≥220		
Heart Rate	<40		40-49		50-89	90-110	111-129	130-139	≥140
Level of Consciousness					Alert			Voice or Pain	Unresponsive or fitting

Figure 1.8 Early warning score (EWS) in Wellington Hospital. Permission to publish image granted by the Intensive Care Unit, Wellington Regional Hospital(83))

The ASU consists of twelve beds of which two are assessment beds. The ASU nursing staff will triage and assess every new patient and inform the registrar on call about the urgency of the patient's condition. They are also all skilled in wound and drain care, as well as inserting lines and tubes (nasogastric (NG) tubes and indwelling urinary catheters (IUC)).

The ASU in Wellington Hospital has dedicated imaging slots (two US and one CT scan) each morning during weekdays. Additional imaging in the form of US or CT scans can be performed 24 hours a day, seven days per week. However, US access is limited during the weekend and out of hours as there are no on-call sonographers available. Furthermore, CT scans between 11pm and 7am are reserved for those who are thought to have a life or limb threatening condition.

Patients requiring an acute operation are booked via an electronic booking form. A booking category is assigned to each case: category 1 means immediate operation, category 2 an operation within 2 hours, category 3 an operation within 6 hours and category 4 an operation within 24 hours. There

also exists categories 5 and 6 but these are never used by the department of general surgery.

There is a general surgery afternoon acute theatre list from 1pm until 4pm, most weekdays, this is in addition to, two acute theatres available to all surgical specialities from 7am until 11pm.   Between 11pm and 7am if an acute theatre is used it is for life or limb threatening emergency surgery only (e.g., Category 1 & 2 cases).   Prioritisation to access an acute theatre depends on the booking category and the time spent on the waiting list.

The ASU is for acute admissions only and patients are usually transferred to the general surgery ward when their stay extends past forty-eight hours or if they have an operation. No post-operative patients go back to the ASU.

The discharge of patients from ASU is organised in the same way all hospital discharges are organised. Patients receive a discharge letter and if required a prescription. Patients that have an unclear diagnosis, but are fit enough for discharge receive a 'blue card' so they can re-present to ED if necessary and be re-referred directly to the ASU without further delays in ED.

1.8 Measuring health care performance

Policy makers, researchers and health care providers use quality indicators, or performance measures, to measure and improve the quality of care provided to patients. Previous research and experience has shown that quality indicators and performance measurement improve health care outcomes[84].

Healthcare performance measurement is the process of collecting, analysing and/or reporting information regarding the performance of a healthcare organisation, system or component. It aims to evaluate whether outputs are in line with what was intended or should have been achieved[84].

Performance indicator or key performance indicator (KPI) is a type of performance measurement. KPIs evaluate the success of an organisation or of

a particular project or implementation in which it engages. Often success is simply the repeated, periodic achievement of some levels of operational goal, in case of health care: costs, length of stay, re-admission rates, morbidity, mortality or patient satisfaction(84).

Examples of health care performance measuring institutes

The National Institute for Health and Care Excellence (NICE)(85).

NICE was originally set up in 1999 as a special health authority, to reduce variation in the availability and quality of NHS treatments and care in the UK.

Aims:

- Produce evidence-based guidance and advice for health, public health and social care practitioners.
- Develop quality standards and performance metrics for those providing and commissioning health, public health and social care services.
- Provide a range of information services for commissioners, practitioners and managers across the spectrum of health and social care.

American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP)(86).

ACS NSQIP is a national surgical quality improvement effort with a data collection platform for tracking surgical outcomes and process measures. ACS NSQIP was started in the Veterans Health Administration (VHA). In the mid-1980s the VHA was criticized for their high operative mortality and Congress passed a law which mandated the VHA to report their outcomes in comparison to national averages. In 1991 the National Veteran's Administration Surgical Risk Study (NVASRS) began in 44 Veteran's Administration Medical Centers. In 1994 NVASRS was expanded to all 128 VHA hospitals that performed surgery. The name was then changed to the National Surgical Quality Improvement Program. It rapidly expanded to include nearly 500 hospitals within its first

decade, however, participating hospitals are more commonly larger teaching hospitals and tertiary centres (86, 87).

Aims:

- Prevent surgical complications
- Reduce mortality of participating hospitals
- Reduce costs

Health care performance measurement in New Zealand

New Zealand does not have a national audit system that collects data about morbidity, mortality or length of stay of patients admitted to the hospital. Although, a programme from the Health Quality and Safety Commission New Zealand, the Perioperative Mortality Review Committee (POMRC), collects data of perioperative deaths. Its aim is to reduce these deaths and improve the quality of the health system and, outcomes for patients(88).

In February 2001 the RACS introduced a Surgical Audit Task Force, to develop models of best practice for surgical audit(89). The purpose of audit, as outlined by the college, is to examine current practice and whether the performance meets existing standards.

A surgical audit involves:

- Collection and measurement of clinical activities and outcomes
- Analysis and comparison using standards, performance indicators an outcome parameters
- A peer review process with a feedback mechanism to redress problems.

The key feature of audit is that it involves reviewing actual surgical performance, including outcomes. The clinical experience is compared with evidence based practice. As such, it should be a stimulus and source of material for learning and quality improvement.

The aims of audit are:

- To identify ways of improving and maintaining the quality of care for patients
- To assist in the continuing education of surgeons
- To help make the most of resources available for the provision of surgical services

As part of the College's Continuing Professional Development program (CPD), all surgeons who conduct operative procedures in hospitals, day surgery units or private rooms are required to participate in a surgical audit each year, and to submit such an audit for peer review(89).

The department of general surgery in Wellington hospital complies with the audit guidelines of the college and performs a biannual morbidity audit meeting per general surgical consultant. Furthermore, there is a weekly morbidity and mortality meeting discussing the cases of that week. Both meetings are mandatory for all consultants and registrars working within the department of general surgery.

A limitation of the current performance measurement is that there are no departmental guidelines concerning treatment of patients within the department of general surgery that can guarantee a standard of care. Therefore, when discussing cases in the morbidity and mortality meeting there is no a comparison against an outlined or approved standard, but more against what is thought to be best practice.

Implementation of new guidelines, the challenges

Innovation has been defined as "the intentional introduction and application within a role, group, or organization, of ideas, processes, products or procedures, new to the relevant unit of adoption, designed to significantly benefit the individual, the group, or wider society"(90). Implementation is seen as one of the four stages of innovation: dissemination, adoption, implementation and continuation(91). However, a large number of change initiatives fail due to

unfocused and insecure management and lack of systematic project management(92).

In case of the implementation of guidelines, it became apparent in the late 1980s that one of the main problems with the introduction is that professionals do not spontaneously use guidelines as intended by the developers(93). Articles titled "Wanted: guidelines that doctors will follow" were a wake-up call for many guideline developers(94, 95). Similar to most other people, health professionals proved not to be rational actors who used guidelines immediately once they were published. There is extensive evidence that the level of use of guidelines affects outcomes in patients(96). To determine whether a guideline is effective, one has to be certain that the guideline has been put into practice by the professionals. Otherwise, it's effect may be under or overestimated which is known as a "Type III error"(97). Therefore, actively auditing and updating an implemented guideline is essential to ensure its effectiveness.

1.9 Summary

Abdominal pain has remained one of the most challenging presentation in ED and over the last years multiple algorithms have been proposed to improve diagnostic accuracy. With the introduction of the CT scan, there is now a diagnostic tool with a high diagnostic accuracy that significantly decreases the incidence of patients being diagnosed with NSAP. On the other hand, recent studies have shown that scanning all patients presenting with abdominal pain leads to over radiation, increased waiting times and hospital costs. Therefore a more selective use should be advocated.

ED presentation rates have been steadily increasing over the last two decades(2, 3). This has a potential impact on other services with increasing numbers of acute admissions. There are no standard measurements (KPI's) of efficiency and quality of care for patients admitted with abdominal pain.

Differentiating urgent patients from non-urgent patients in ED can help with this as we know from previous studies that NSAP represents the largest proportion of the patients presenting with abdominal pain to the ED. Using a more selective approach would reduce unnecessary use of hospital resources and with that improve the flow for the urgent patients that require access to hospital resources within a timely fashion.

Developing a guideline or a pathway to improve the clinical assessment of a patient presenting with abdominal pain to the general surgery department will ultimately benefit patient care.

1.10 Aims of this PhD are:

Section 1 Evaluating the current process of how patients presenting with abdominal pain to the general surgery department are assessed

- To review the diagnostic process and the use of additional imaging for patients presenting to general surgery with acute abdominal pain over the last decade.

- To review our institution's appendicectomies and the negative appendicectomy rate (NAR) during the last decade.

- To evaluate our institutions CT scan requests for patients presenting with acute and new abdominal pain and to determine how many of these scans were considered clinically indicated.

- To evaluate the patient's progress from acute presentation to arrival in the operating theatre and to identify where delays occur.

Section 2 Evaluating the current evidence of how patients who present with acute abdominal pain to the hospital are assessed

- To identify the current evidence for diagnostic pathways for patients presenting with abdominal pain and their effect on final outcomes such as morbidity, mortality and length of stay.

Section 3 Stepwise introduction of a new pathway to benefit the assessment of patients presenting with acute abdominal pain

- To evaluate whether we can accurately differentiate the urgent from the non-urgent patients presenting with abdominal pain prior to the use of advanced imaging.

- To evaluate whether the implementations made to the surgical department resulted in a reduction in length of hospital stay and a reduction in the use of additional imaging (US or CT scans) for patients presenting with NSAP, without increasing the number of re-presentations to ED or re-admissions.

Section 1

Evaluating the current process of how patients presenting with abdominal pain to the general surgery department are assessed.

Chapter 2: Acute abdominal pain- Changes in the way we assess it over a decade.

2.1 Introduction

Diagnosing patients presenting with acute abdominal pain is a challenge, as outlined in the introduction(2, 3, 98). Over the last decade implementations and new diagnostic tools have been introduced to improve the diagnostic process. The first was improved access to CT scans to aid early and accurate diagnosis(3, 39, 43, 99). A later implementation was the introduction of the 6-hour target in the ED, aiming to improve patient flow (62, 65, 71). The last implementation was the introduction of ASU's worldwide, mainly aiming to improve fast assessment of surgical patients and to reduce pressure on the ED(76-78).

The above mentioned implementations have the aim to improve the diagnostic process for patients presenting acutely to the hospital, including patients presenting with acute abdominal pain. Optimally, they aim to reduce the number of complications and length of hospital stay. Consultants and registrars within the department of general surgery in Wellington Hospital anecdotally reported a long transit time between patients presenting to the ED and having their operation or being discharged. No obvious cause could be easily identified.

Therefore, the aim of this study was to review the diagnostic process and the use of additional imaging for patients presenting to general surgery with acute abdominal pain over the last decade.

2.2 Methods

The number of acute surgical admissions for the years 2004, 2009 and 2014 were retrospectively reviewed. Patients were categorised depending on the presenting complaints of abdominal pain, perianal/pilonidal abscess, other abscess/skin infection and other (including post-operative complications, hernia and gastro intestinal bleeding) and their admission numbers were reviewed over the study period.

Inclusion criteria

Of the patients presenting with acute abdominal pain, two-hundred were selected (by computer randomisation) from each of the three years, thereby creating three groups of two hundred patients each. Patients with symptoms for longer than 7 days were excluded. This is an arbitrary time frame, but similar to comparable studies(28, 39, 100). It was chosen because one can argue that pain that exists for more than 7 days is unlikely to be caused by an acute and new inflammatory process. Patients who had recurrent or chronic abdominal pain, had a postoperative complication (<30 days) or were younger than 16 years old were excluded. In New Zealand, patients under the age of 16 are minors and in Wellington Hospital these patients are cared for by paediatric physicians or surgeons.

Data collection

Data were collected for the selected patients from theatre databases, ED and admission notes, discharge letters and radiology reports. From all these sources patient characteristics and comorbidities were obtained. The times and dates of ED presentations, admissions, any imaging, operations and discharge information were collected in order to calculate the intervals between them. The presentation date and time was chosen as the time that the patient registered to ED as this time would not have been influenced by availability of triage nurses or doctors. The time a scan (US or CT) was performed was chosen as imaging time, because the time of reporting a scan can be dependent on radiology

workload. The time a patient entered theatre was chosen as theatre time, because this time is not influenced by anaesthetic time. In-hospital and ninety-day morbidity and mortality were also collected. Information about the final diagnosis was obtained from discharge letters, radiology or theatre reports and post discharge clinic letters.

Implementations

During the study period several changes were made at Wellington Regional Hospital designed to improve patient safety, admission efficiency and early diagnosis. In 2005 access to theatre after 23:00 was reduced, becoming accessible only for life or limb threatening emergency surgery. In May 2009 the 6 hour rule in ED was implemented, to encourage early referral or discharge and to reduce ED waiting times and in July 2013 an ASU was opened, which included a consultant led acute service with improved access to emergency theatre and dedicated slots for imaging (one CT scan and two US, Monday-Friday).

Ethical approval

The thesis protocol including of the three sections, was submitted for evaluation to the Health and Disability Ethics Committee in New Zealand. Ethical approval was granted for all studies included in this thesis (reference: 16/NTB/131). Furthermore, the thesis protocol was also reviewed and approved by the Māori Partnership Board, Capital & Coast District Health Board, and the Research Advisory Group Māori (RAG-M).

Statistical analysis

All data analysis for the different projects in this thesis were done using the same statistical principals. The data were analysed using SPSS® software (SPSS 23, Chicago, Illinois, USA). Data were expressed as mean and standard deviation (SD) for normally distributed continuous data, median (interquartile

range (IQR)) for non-parametric data and count (%) for discrete data. Continuous data were compared between groups using One-Way ANOVA for normally distributed data and Kruskal-Wallis test for nonparametric data. Chi square tests were used for discrete data. A p value of ≤0.05 was considered statistically significant.

2.3 Results

The Wellington population increased in size by 9.6% from 2004 to 2014(83), ED presentations increased by 54.2% over the same period, and the number of acute surgical admissions increased by 87.2% (figure 2.1 and table 2.1). Surgical admissions were categorised by presenting complaint. Abdominal pain accounted for the majority of the acute surgical admissions in each year.
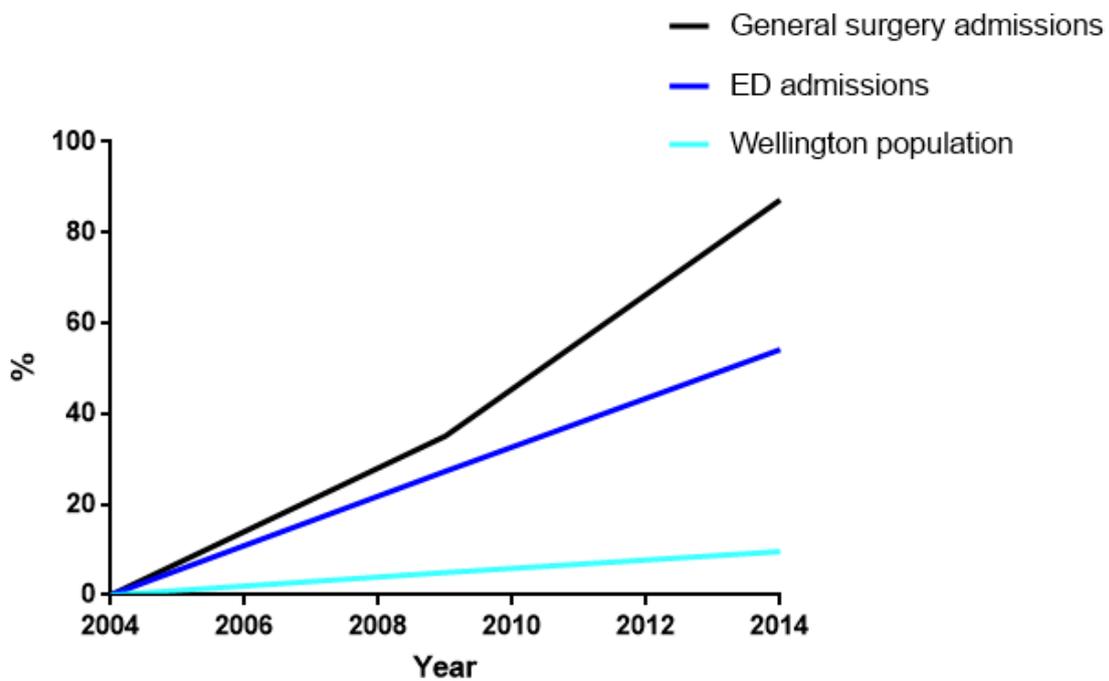
Figure 2.1 Proportional increase of Wellington population, ED presentations and surgical admissions over a decade

Table 2.1 Population and admission characteristics.

	2004	**2009**	**2014**
Population estimate Wellington CCDHB region	270700	285300	296700
Number of ED presentations	39639	50473	61113
Total number of surgical admissions	1462	1975	2737
Number of surgical admissions per 100.000 inhabitants	540	692	922
Reason for admission (%)			
Abdominal pain	1108 (75.8)	1420 (71.9)	1928 (70.4)
Anal/peri-anal abscess	100 (6.8)	131 (6.6)	133 (4.9)
Other abscess/local infection	161 (11.0)	138 (7.0)	170 (6.2)
Other[#]	93 (6.4)	286 (14.5)	506 (18.5)

CCDHB; Capital and Coast District Health Board, ED; emergency department. # includes: postoperative complications, hernia, bleeding per rectum, etc.

Patient characteristics were compared between the three groups of two-hundred patients of each year. The mean age of the included patients did not differ significantly between the three groups and was approximately 49 years, almost 60% of the study population was female and the majority had the New Zealand/European ethnicity (table 2.2). The majority of the patients were referred via the ED (61.3%). Significant comorbidities were uncommon, but of relevant medical history, previous abdominal surgery was the most recorded (24.5%).

Table 2.2 Patient characteristics.

	2004 (N=200)	2009 (N=200)	2014 (N=200)	p value
Age (mean, [SD])	48.9 [21.4]	49.6 [22.7]	49.4 [23.8]	0.951
Gender (%)				
Female	119 (59.5%)	121 (60.5%)	119 (59.5%)	0.973
Ethnicity (%)				
NZ European	157 (78.5%)	137 (68.5%)	160 (80.0%)	0.126
Maori	18 (9.0%)	26 (13.0%)	18 (9.0%)	
Pacific	9 (4.5%)	14 (7.0%)	6 (3.0%)	
Asian	13 (6.5%)	13 (6.5%)	12 (6.0%)	
Other	3 (1.5%)	10 (5.0%)	4 (2.0%)	
Referrer				
ED	113 (56.5%)	129 (64.5%)	126 (63%)	0.218
Diabetes				
Yes (%)	16 (8.0%)	15 (7.5%)	18 (9.0%)	0.856
Heart disease				
Yes (%)	38 (19%)	31 (15.5%)	33 (16.5%)	0.626
COPD				
Yes (%)	8 (4.0%)	5 (2.5%)	7 (4.5%)	0.696
CKI				
Yes (%)	9 (4.5%)	9 (4.5%)	11 (5.5%)	0.859
Previous abdominal surgery Yes (%)	68 (34.0%)	71 (35.5%)	86 (43.0%)	0.150

NZ; New Zealand, ED; emergency department, COPD; Chronic Obstructive Pulmonary Disorder, CKI; Chronic Kidney Injury.

Median time from ED presentation to surgical admission was significantly different across the three groups, at 9 hours in 2009 compared to 4 and 3 hours in 2004 and 2014 respectively (table 2.3). No differences were observed between mean haemoglobin (Hb) and WCC levels, but mean CRP levels were lower in 2014 compared to 2004 and 2009 (p=0.013). The number of patients who had a CRP level measured increased from 103 in 2004 to 189 in 2014.

Table 2.3 Patient work up and theatre.

	2004 (N=200)	2009 (N=200)	2014 (N=200)	p value
Time to admission	4.0 (3.0-6.0)	9.0 (6.0-13.0)	3.0 (1.0-5.0)	<0.001
Blood test				
Hb	136.9 [22.7]	138.5 [18.4]	138.1 [23.7]	0.731
WCC	11.9 [4.6]	12.0 [5.2]	11.2 [4.5]	0.199
CRP	53.1 [72.9]	56.6 [72.0]	35.9 [57.5]	0.013*
US (%)	64 (32.0)	62 (31.0)	57 (28.5)	0.614
Time to US	23.0 [15.6]	27.5 [23.7]	19.2 [12.7]	0.048*
CT scan (%)	52 (26.0)	69 (34.5)	90 (45.0)	<0.001*
Time to CT scan	34.9 [35.0]	20.3 [18.7]	17.2 [29.0]	0.001*
Theatre (%)	84 (42.0)	65 (32.5)	69 (34.5)	0.075
Time to Theatre	11.0 (8.0-21.5)	18.0 (10.0-26.8)	20.0 (7.25-45.0)	0.014*

Median (IQR) for non-parametric data and mean [SD] for parametric data. Times are in hours. Hb = Haemoglobin (g/L), WCC = White Cell Count (10^9/L), CRP = C-Reactive Protein (mg/L).US = ultrasounds scan, CT scan = Computed Tomography scan.
* Significant findings (p ≤0.05)

The use of abdominal X-rays decreased across the study period, 133 (66.5%) in 2004, 111 (55.5%) in 2009 and 97 (48.5%) in 2014, (p=0.001). The number of patients undergoing US did not differ between the three groups, but the time from presentation to scan was statistically significant shorter in 2014 compared to 2004 and 2009 (p=0.048). The proportion of the patients receiving a CT scan increased significantly between 2004 and 2014 (from 26.0% in 2004 to 45.0% in 2014, p<0.001), while time to CT scan reduced (p=0.001). During the study period an increased percentage of the CT scans were reported as

negative for acute abdominal pathology, this was 31 (34.4%) in 2014, compared to 7 (10.1%) in 2009 and 9 (17.3%) in 2004 (p<0.001).

There was a trend towards a reduction of the proportion of patients presenting with acute abdominal pain that received an operation between 2004 and 2014 from 84 (42.0%) in 2004 to 69 (34.5%) patients in 2014 (p=0.075). Time from ED presentation to theatre increased during the study period, from a median of 11 hours in 2004 to 20 hours in 2014 (p=0.014).

Of the patients receiving an operation, 60.0% had an appendicectomy. The proportion of negative appendicectomies did not differ between the three groups, 8 in 2004 (13.6%), 10 in 2009 (22.2%) and 5 in 2014 (12.2%) (p=0.542).

Non-surgical diagnosis (NSD) included all patients with NSAP, constipation and gastro enteritis. In 2004 fewer patients had an NSD (23.5%) compared to 2009 (25.0%) and 2014 (33.0%), p = 0.035. Table 2.4 summarises the final diagnosis of all patients included in the study, there was no significant difference in the final diagnoses between the three groups. Patients with the final diagnosis NSD, but who had an operation, were patients with a negative laparoscopy.

Overall length of stay (LOS) was shortened in 2014 with a mean of 3.2 days compared to 2004 (4.1 days) and 2009 (4.8 days) (p=0.015).

Table 2.4 Final diagnosis

	2004 N (%)		2009 N (%)		2014 N (%)	
	Non-op	**Op**	**Non-op**	**Op**	**Non-op**	**Op**
NSD	39 (33.6)	8 (9.5)	40 (29.6)	10 (15.4)	61 (46.6)	5 (7.2)
Appendicitis	0 (0)	51 (60.7)	2 (1.5)	35 (53.8)	3 (2.3)	36 (52.2)
Diverticulitis						
Uncomp	10 (8.6)	1 (1.2)	17 (1.5)	0 (0)	14 (10.7)	0 (0)
Comp	2 (1.7)	3 (3.6)	2 (1.5)	0 (0)	1 (0.8)	2 (2.9)
Pancreatitis	12 (10.3)	0 (0)	18 (13.3)	0 (0)	11 (8.4)	3 (4.3)
Gall stones	12 (10.3)	1 (1.2)	10 (7.4)	0 (0)	11 (8.4)	0 (0)
Cholecystitis	7 (6.0)	5 (6.0)	8 (5.9)	2 (3.1)	11 (8.4)	4 (5.8)
SBO	18 (15.5)	3 (8.8)	18 (13.3)	1 (1.5)	8 (6.1)	4 (5.8)
LBO	4 (3.4)	6 (7.1)	2 (1.5)	4 (6.2)	2 (1.5)	2 (2.9)
GI ischaemia	0 (0)	3 (3.6)	0 (0)	3 (4.6)	0 (0)	1 (1.4)
P/D ulcer	0 (0)	0 (0)	1 (0.7)	3 (4.6)	1 (0.8)	2 (2.9)
Other[#]	2 (10.3)	3 (3.6)	17 (12.6)	7 (10.8)	8 (6.1)	10 (14.5)
Total	**116**	**84**	**135**	**65**	**131**	**69**

Non-op; non-operative, Op; operative, NSD; non-surgical diagnosis, comp; complicated, SBO; small bowel obstruction, LBO; large bowel obstruction, GI; gastrointestinal, P/D ulcer; peptic/duodenal ulcer
includes: Patients with a final diagnosis covered by other specialties (gynaecology, urology, gastro-enterology and vascular), epiploic appendagitis, torted epiploic appendage or omentum, gastric volvulus in a hiatus hernia, newly diagnosed cancer not causing obstruction, etc.

2.4 Discussion

Over the study period the overall number of admissions to the department of general surgery and the number of patients admitted with abdominal pain has increased remarkably. There was an increased use of CT scans for patients presenting with abdominal pain associated with a higher percentage of these scans being negative for acute pathology. Furthermore, more patients were admitted with a non-surgical diagnosis.

Patients presenting with abdominal pain usually receive a standard work up consisting of history taking and clinical assessment, followed by bloods, urine analysis and if considered necessary, abdominal and/or chest X-ray. The minimal role for plain radiography for patients presenting with non-traumatic abdominal pain has been discussed in many papers(39-42) However, because they are easily obtained and can be useful in selected cases (e.g. bowel obstruction, perforated viscus), they were still used in approximately 50% of the patients presenting with abdominal pain in the 2014 group.

For those that do not immediately or obviously need an intervention WCC and CRP are often used as triage markers to differentiate urgent from non-urgent patients. During our study period all patients had WCC tested on admission and CRP tests were increasingly requested during the study period, although both markers have minimal clinical accuracy in differentiating between urgent and non-urgent presentations(36, 38, 101).

During the study period an increasing proportion of patients received a CT scan to aid with diagnosis. However, this increase was also associated with an increase in the number of negative scans. A number of studies have published results with high sensitivities and specificities for CT scanning in the diagnosis of patients with acute, non-traumatic abdominal pain. This increase in diagnostic accuracy, however, has not been associated with a decrease in complication rates or length of stay for this patient group(39, 44). Furthermore, CT scans are costly and can delay early diagnosis and length of stay if a CT scan cannot be arranged within a helpful timeframe(46). The described challenge implies that there is a balance between necessary and unnecessary

CT scans and raises the question what percentage of negative scans is considered acceptable. This topic is further examined in chapter 4.

Four and six hour rules or targets have been implemented worldwide to reduce ED waiting times and to improve hospital flow. A number of centres have published their results and conclude that patient safety is not compromised by these rules and that they do not cause an increase in imaging(64, 65). However, in the current study we have observed a significant increase in surgical admissions, and it is possible that this is at least in part a negative consequence of implementation of the 6-hour rule. These results are comparable to previous published studies in both Australia and the UK(62, 67, 71, 72). Furthermore, there was a significant increase in the proportion of patients with a final non-surgical diagnosis who had been admitted under general surgery. Gastro-enteritis, gastritis, NSAP and constipation were included in this group, these are all conditions that generally do not require admission. Further work is needed to understand what factors are driving the increased admission of patients to general surgery, and particularly the increased proportion of these patients with non-surgical problems.

An appendicectomy was the most commonly performed acute operation (60.0%). The NAR did not differ between the three study years (p=0.542). One can argue that because of the increased use of imaging, mainly CT scanning, the NAR should have decreased within the study period. This topic is further examined in chapter 3.

An ASU was implemented in Wellington Regional Hospital in 2013 to facilitate early assessment and diagnosis of patients referred via ED and the GP. Patients referred via the GP could present straight to ASU and would thereby reduce pressure on the ED. Even though the implementation of an ASU assured improved access to theatre and additional imaging, this study shows that the time to theatre increased rather than decreased between 2004 and 2014 (median of 11 hours in 2004 to 20 hours 2014, p=0.014). This may be partly due to the reduced access to theatre out of hours. This topic is further examined in chapter 5.

Time to US and CT scan, on the other hand decreased significantly (p = 0.048 and p = 0.001 respectively). Length of hospital stay (mean 3.2 days) in the 2014 group, post introduction of the ASU is comparable to previous published results(78, 102). This reduction across the study period is likely to be multifactorial. Faster access to imaging is likely a significant factor, but it is also possible that the increased proportion of nonsurgical admissions is contributing. If access to theatre can be improved, length of stay may well reduce further. This would have both cost effective implications and improve patient satisfaction, furthermore, it may reduce complications.

Limitations of our study are in the retrospective design and the different time periods of the three groups. Although, the major implementations such as the 6 hour ED rule and the ASU have been contributing to our current diagnostic pathway, other unidentified changes during the study period may have contributed as well.

The years (2004, 2009 and 2014) that we have selected to review and only reviewing 200 patients from each year was a pragmatic decision. The aim was to observe the changes over a decade, data collection started in 2015. In addition evaluation of all patients that presented with abdominal pain in the selected years though ideal, would have created a workload beyond the scope of this project and provided minimal further information.

Also, no power analysis was performed prior to the data collection, but the size (two hundred patients) of the three cohorts was chosen to facilitate statistical comparison between them. Bias may have been introduced as there is always a difference in patient management between surgical consultants, this should have been minimised by the random selection of the patients. This random selection should also have minimised any selection bias.

2.5 Conclusion

Over the last decade, the number of acute surgical admissions has increased. There is an increase in the use of CT scans, but more of these are negative for any pathology. Furthermore a greater proportion of patients admitted under general surgery have a non-surgical diagnosis. These observations suggest that there is need to carefully assess the processes by which patients are admitted and investigated.

Chapter 3: Review of appendicectomies over a decade.

3.1 Introduction

As outlined in chapter 2, the most commonly performed acute operation for a patient presenting with abdominal pain to the hospital is an appendicectomy(9, 103). The diagnosis of acute appendicitis is a clinical diagnosis based on a combination of history taking, physical examination and blood work. US or CT scans are used when the clinical presentation is unclear. Over the last decade CT scans have been used more frequently, especially in the elderly population, to exclude other causes of abdominal pain(100, 104, 105).

Operative removal of the appendix remains the standard treatment for acute appendicitis in most hospitals. However, errors in diagnosing acute appendicitis results in unnecessary appendicectomies being performed(106). Negative appendicectomies have obvious patient risks, both surgical and anaesthetic, but also carry an economic burden on the healthcare system(106, 107).

It has been shown that routine diagnostic imaging (US or CT), lowers the NAR in cases of suspected appendicitis to 1.7-6.2%(107-110). While in hospitals where imaging is used selectively, the NAR is between 20.6 and 38.9%(100, 111, 112). On the other hand, routine imaging leads to high rates of unnecessary radiation, has significant cost implications and can strain limited health care resources.

An important finding of the work described in chapter two of this thesis is our institutions increased use of CT scans for patients presenting with abdominal pain. This should ideally lead to a simultaneous reduction in the NAR. Therefore, the aim of this study was to review our institution's appendicectomies and the NAR during the last decade.

3.2 Methods

Inclusion criteria and data collection

A retrospective clinical study was performed in Wellington Regional Hospital. All adult patients (>16 years) who underwent an appendicectomy or a diagnostic laparoscopy on an emergency basis in the years 2004, 2009 and 2014, were included. Cases were identified from the hospital electronic theatre record system.

Data were collected for each patient through theatre databases, ED and admission notes, discharge letters, radiology, histology, and operation reports. Re-presentations and complications were collected from discharge letters and from ED presentations.

Histopathological diagnosis of early appendicitis was made based on the presence of subserosal vessel congestion and perivascular neutrophil infiltrate in all layers of the appendix wall. For acute appendicitis, diagnosis required infiltration of neutrophils in the muscularis propria. For gangrenous appendicitis, diagnosis required haemorrhagic ulceration and gangrenous necrosis that extended to the serosa.

Implementations

During the study period several implementations to improve patient safety and flow were realised, these are explained in the methods section of chapter 2.

Statistical analysis

The data were analysed using the same statistical principles as explained in the methods section of chapter 2. Additional to that, univariate analysis was first performed using a binary logistic regression to determine which variables were significantly associated with a negative appendicectomy.

To identify independent predictors of negative appendicectomies, variables identified as significant in univariate analysis were subsequently included in a stepwise logistic regression analysis.

3.3 Results

A total of 874 patients underwent an appendicectomy, 227 patients in 2004, 308 patients in 2009 and 339 patients in 2014. Patients who underwent a diagnostic laparoscopy generally had an appendicectomy even when the appendix looked macroscopically normal. A total of eighteen patients did not have an appendicectomy. The reason not to proceed with an appendicectomy was: obvious gynaecologic pathology, inflammatory bowel disease (IBD), complicated diverticulitis and surgeons preference. These patients were excluded from further analysis as their post-operative management differed from the appendicectomy patients.

The median age of the patients who underwent an appendicectomy was 28 years (IQR 21-41) and 50.8% were female. Patient characteristics (age, gender and ethnicity) did not differ significantly between the three groups. During the study period a significantly increasing proportion of the patients with suspected appendicitis, were referred to the department of general surgery via the ED ($p<0.001$). There was no difference in the incidence of medical co-morbidities between the three groups. Medical co-morbidities included heart diseases, previous ischaemic events, diabetes, chronic obstructive pulmonary disease (COPD), IBD, and medication that may influence peri- and post-operative management including anticoagulation, corticosteroids and other immunosuppressing medication (see table 3.1).

Table 3.1 Patient characteristics appendicitis

	2004 (N=227)	2009 (N=308)	2014 (N=339)	p value
Age (median, (IQR))	29 (22-43)	27 (20-41)	28 (21-39)	0.208
Gender (%)				
Female	116 (51.1%)	157 (51.0%)	171 (50.4%)	0.985
Ethnicity (%)				
NZ/European	164 (72.2%)	205 (66.6%)	246 (72.6%)	0.082
Maori	27 (11.9%)	36 (11.7%)	33 (9.7%)	
Pacific	20 (8.8%)	30 (9.7%)	30 (8.8%)	
Asian	13 (5.7%)	26 (8.4%)	29 (8.6%)	
Other	3 (1.3%)	11 (3.6%)	1 (0.3%)	
Referrer (%)				
ED	87 (38.3%)	129 (41.9%)	182 (53.7%)	<0.001*
GP	121 (53.3%)	161 (53.9%)	141 (41.6%)	
Other	19 (8.4%)	12 (3.9%)	16 (4.7%)	
Medical co-morbidities (%)	25 (11.1%)	28 (9.1%)	22 (6.5%)	0.152
Previous abdominal surgery (%)	60 (26.4%)	33 (10.7%)	61 (18.0%)	<0.001*

NZ; New Zealand; ED; emergency department; GP; general practitioner.
* Significant findings (p ≤0.05)

Standard work-up for patients with suspected appendicitis included WCC and CRP. The median level of both inflammatory markers did not differ significantly between the three groups (table 3.2).

Table 3.2 Work up; bloods and imaging.

	2004 (N = 227)	2009 (N = 308)	2014 (N = 339)	p value
Blood test				
WCC	12.3 (9.5-15.9)	13.1 (10.0-16.2)	12.7 (9.2-15.8)	0.313
CRP	24 (7-67)	17 (4-65)	19 (5-47)	0.101
Imaging				
Yes (%)	46 (20.4%)	67 (21.8%)	102 (30.2%)	0.010*
Modality				
US (%)	24 (10.6%)	33 (10.7%)	38 (11.2%)	0.739
CT (%)	22 (9.7%)	34 (11.0%)	64 (18.9%)	0.001*

Median (IQR) for non-parametric data. WCC; White Cell Count (10^9/L), CRP; C-Reactive Protein (mg/L), US; ultra sounds scan, CT; Computed Tomography scan.
* Significant findings (p ≤0.05)

In total ninety-five patients underwent an US scan during the study period. Thirty-two (33.7%) were reported positive for appendicitis, out of these twenty-seven had histologically proven appendicitis (positive predictive value (PPV) = 81.8%). Sixty-two (65.3%) were reported negative or inconclusive for appendicitis out of which thirty-three patients had appendicitis based on histology (negative predictive value (NPV) = 46.8%).

One-hundred-and-twenty patients had a CT scan, ninety-five were positive for appendicitis out of which eighty-four had appendicitis (PPV = 88.4%). For twenty-five patients the CT scan was negative or inconclusive for appendicitis, of these patients fourteen had appendicitis (NPV = 44.0%). The use of pre-operative CT increased during the study period from twenty-two (9.7%) patients in 2004 to sixty-four (18.9%) patients in 2014 (p=0.001). The

median age of the patients who had a CT scan before theatre was 52.5 (42-62) years.

Time from admission to theatre increased significantly during the study period (table 3.3). In 2004, fifty-nine (26.0%) patients had their operation between 23:00-08:00, compared to twenty-seven (8.8%) patients in 2009 and eight (2.4%) patients in 2014 (p<0.001). A total of 236 (27.0%) patients had their operation more than 24 hours after admission, this group increased in size during the study period (18.1% in 2004, 28.3% in 2009 and 31.8% in 2014, p<0.001). Of the patients operated within 24 hours, 6.4% had a complication compared to 6.8% for the group operated more than 24 hours after admission (p=0.839).

Table 3.3 Theatre and histology characteristics, LOS, complications and re-admissions.

	2004 (N = 227)	2009 (N = 308)	2014 (N = 339)	p value
Time to theatre	12.4 (8.2-20.7)	18.2 (11.4-25.5)	18.5 (10.8-26.6)	<0.001*
Operation				<0.001*
Laparoscopic	78 (34.4%)	256 (83.1%)	309 (91.2%)	
Open	137 (60.4%)	17 (5.5%)	11 (3.2%)	
Converted	12 (5.3%)	35 (11.4%)	19 (5.6%)	
Histology				0.014*
Appendicitis	149 (65.6%)	233 (75.6%)	258 (76.1%)	
Negative	66 (29.1%)	62 (20.1%)	66 (19.5%)	
Other	13 (5.7%)	13 (4.2%)	15 (4.4%)	
Time from theatre to discharge	1.9 (1.3-3.4)	1.3 (1.0-3.0)	1.1 (0.9-2.1)	<0.001*
Overall LOS	2.7 (1.9-3.9)	2.4 (1.7-4.0)	2.1 (1.7-3.2)	0.001*
Complication	17 (7.5%)	22 (7.1%)	18 (5.3%)	0.501
Re-presentation	11 (4.8%)	24 (7.8%)	19 (5.6%)	0.321

Median (IQR) for non-parametric data. Time from presentation to theatre in hours, from theatre to discharge and overall LOS in days. Other = Neoplasm, endometriosis, inflammatory bowel disease, worm infection. LOS, length of stay.
* Significant findings (p < 0.05)

In 2004, 60.4% of the appendicectomies were open. Laparoscopic surgery gained in popularity during the study period with the result that 5.5% of appendicectomies were open in 2009 and 3.2% in 2014 (p=0.001). The NAR was 22.2% during the study period and decreased significantly between 2004 (29.1%) and 2009 (20.1%) (p=0.004). No significant difference was seen between 2009 (20.1%) and 2014 (19.5%) (p=0.630).

Complicated appendicitis (gangrenous or perforated) on histologic examination included forty-eight (21.1%) patients in 2004, sixty-six (21.4%) patients in 2009 and seventy-seven (22.7%) patients in 2014 (p=0.884). Other histology findings included neoplasm (4.0%), endometriosis (0.5%), worm infection (0.3%) and IBD (0.3%). Overall Fifty-seven (6.5%) patients had a complication, including; ileus, wound infection, intra-abdominal collection, pneumonia, clostridium difficile infection and one patient had heart failure post-operative requiring ICU support for two days. Thirty day mortality was zero for the patients included in this study. The number of re-presentations (including re-admissions and ED presentations) did not differ significantly between the three groups.

The final diagnosis in 73.2% of the patients was appendicitis. A gynaecologic cause for the pain was found in 5.6% of the patients, no cause for the pain was found in 13.3%. Other findings were described in 1.5% and included; cholecystitis and Meckel's diverticulitis. No significant difference in final diagnosis was observed between the three groups (see table 3.4).

Table 3.4 Final diagnosis for all patient with a presumed diagnosis of appendicitis

	2004 (N=227)	2009 (N=308)	2014 (N=339)
Appendicitis	149 (65.6%)	233 (75.6%)	258 (76.1%)
NSAP	43 (18.9%)	34 (11.0%)	39 (11.5%)
Gynaecologic	15 (6.6%)	17 (5.5%)	17 (5.0%)
Neoplasm	10 (4.4%)	10 (3.2%)	11 (3.2%)
Mesenteric adenitis	0 (0.0%)	1 (0.3%)	3 (0.9%)
IBD	1 (0.4%)	1 (0.3%)	1 (0.3%)
Torted omentum/epiploic	1 (0.4%)	2 (0.6%)	4 (1.2%)
Diverticulitis	4 (1.8%)	3 (1.0%)	2 (0.6%)
Other	4 (1.8%)	4 (1.3%)	5 (1.5%)

NSAP; non-specific abdominal pain

NAR was higher in the patients under the age of 30 years old and in females (p<0.001) (table 3.5). An elevated WCC (>12.0 10^9/L) and CRP (>25 mg/L) were both independently associated with appendicitis. The NPV for a combined low WCC and CRP was 42.6%, conversely the PPV for both an elevated WCC and CRP, was 88.0%.

The complication rate and the re-admission rate did not differ between patients with appendicitis and patients with a negative appendicectomy. Median length of stay (LOS) for patients with appendicitis was 2.3 (1.7-3.8) days, compared to 2.5 (1.3-4.1) days for patients with a negative appendicectomy (p=0.870).

Table 3.5 Univariate and multivariate analysis for signs and symptoms for appendicitis

	Appendicitis N=654	Negative N=194	Univariate analyse Odds ratio and (95% CI)	p value	Multivariate analyse Odds ratio (95%CI)	p value
Gender						
Female	299 (45.7%)	125 (64.4%)	2.15 (1.54-3.00)	**<0.001***	1.92 (1.30-2.82)	**<0.001***
Age (<30 years)	341 (53.0%)	130 (70.7%)	2.14 (1.50-3.05)	**<0.001***	2.31 (1.60-3.32)	**<0.001***
Referrer						
ED	336 (51.4%)	79 (40.7%)	1.45 (1.04-2.02)	**0.027***	1.17 (0.82-1.67)	**0.010***
Bloods						
WCC (>12.0 10^9/L)	408 (62.4%)	66 (34.0%)	3.22 (2.30-4.50)	**<0.001***	3.41 (2.33-4.98)	**<0.001***
CRP (>25 mg/L)	267 (40.8%)	50 (25.8%)	2.09 (1.45-3.03)	**<0.001***	1.46 (1.20-1.77)	**<0.001***
LOS (>2days)	375 (57.3%)	113 (58.2%)	0.88 (0.63-1.23)	**0.439**	0.69 (0.49-0.99)	**0.559**
Complications	47 (7.2%)	9 (4.6%)	1.59 (0.77-3.31)	**0.208**	1.79 (0.79-4.03)	**0.163**
Re-admissions	42 (6.4%)	11 (5.7%)	1.14 (0.58-2.26)	**0.704**	0.90 (0.44-1.86)	**0.789**

ED; emergency department, WCC; White Cell Count (10^9/L), CRP; C-Reactive Protein (mg/L), LOS; length of stay.

* Significant findings (p < 0.05)

3.4 Discussion

Overall the NAR decreased during the study period, with the most significant decrease seen between 2004 and 2009. However the higher NAR in 2004 seems to be a statistical aberration that we can't fully explain as a previous study from our hospital collecting data between June 2002 and February 2004 reported a NAR of 21.0%(113). There was no significant change in the NAR between 2009 and 2014. It will be difficult to determine a single factor that contributed to the high NAR in 2004. It might be related to the introduction of laparoscopic surgery as this may have lowered our threshold to perform diagnostic laparoscopy for patients with abdominal pain that did not settle despite no concerning clinical observations or laboratory results.

A microscopically normal appendix was more commonly found in female patients and patients under the age of thirty. Overall, the NAR in our institution is comparable to a multicentre study of 95 hospitals where they reported a NAR of 20.6%(111). Both in our hospital and in these centres, imaging was used selectively.

Standard work up for appendicitis includes laboratory tests and mainly the evaluation of inflammatory markers WCC and CRP. Our results demonstrate that the use of these tests are of limited effectiveness in supporting the diagnosis of appendicitis, especially in patients with normal inflammatory markers, appendicitis cannot be reliably ruled out as the NPV was 42.6% in this study. This is comparable to previous findings in literature(114, 115). The combination of clinical suspicion and raised inflammatory markers results in a higher sensitivity and specificity for diagnosing patients with acute appendicitis(114).

Routine use of imaging is commonly described for patients with suspected appendicitis. Countries in Western Europe mainly use US and report sensitivities between 77-91%(40, 116), however, US accuracy is operator and hospital dependent and significantly lower sensitivities have been reported as well(117, 118). While studies from centres mainly in the United States of America use CT because of the well-established accuracy of this modality, with a sensitivity higher than 90%(107, 109). CT though, is more expensive than US

and carries exposure to radiation risks, the risk of contrast induced allergy and can incur a delay in treatment(107, 119). In studies where routine imaging is used, the prevalence of appendicitis has been reported as being between 13-77%, which means 23-87% of patients have had unnecessary imaging(40, 107, 118).

The use of CT scans increased significantly during the study period. However, most scans were reserved for elderly patients. A recent study showed that in this age group appendicitis is still the most common pathology, but neoplasia and acute colonic diverticulitis, in combination, make up the same proportion of diagnoses(104). With this increase in CT scanning, mainly seen between 2009 and 2014, the NAR did not change concordantly.

Some studies argue that removing a macroscopically normal appendix carries increased length of stay, morbidity, and economic burden(120, 121). However, other studies have found that up to a third of the peri-operative macroscopically normal appendices harbour inflammation and other pathologies when analysed histologically(122, 123). Our own results shows no difference in complications or length of stay in patients who had a normal appendix versus those who had uncomplicated appendicitis. These results are in concordance with other similar studies that show no increase in morbidity in patients who had a negative appendicectomy(111, 112).

Time to theatre increased during the study period, 236 (27.0%) patients had their operation more than 24 hours after presentation to the ED. A recent study showed that short delays up to 24 hours are not associated with increased occurrence of complications, but longer delays result in obvious patient related discomfort, increased length of stay and thereby cost and may be associated with increased rate of wound infections(113, 124). Overall length of stay over the study period decreased, despite the increased time to theatre. This is therefore most likely associated with the increased rate of laparoscopic surgery(125).

Limitations of the study are the retrospective design and by selecting three years (2004, 2009 and 2014) in a decade, there may be selection bias. This is what may have resulted in the relatively high NAR of 29.1% in 2004

which is a clear outlier compared to the other years in this study and a previous study at the same institution(113). A combination of surgical consultants and trainees have contributed to the diagnosis of appendicitis and subsequent operations, thus differences in skill levels could affect outcomes. However, the size of the cohorts selected should limit the effect of this bias. In this study we have included patients who underwent a diagnostic laparoscopy or an appendicectomy.

We don't have the data of the patients who underwent imaging and on the basis of the results did not have an operation. Nevertheless, we can conclude that the increased use of CT scans seen in our institution over the last decade (from 26.0% in 2004 to 45.0% in 2014)(103) is not reflected in a simultaneous reduction in the NAR.

The calculated PPV and NPV for US and CT scans are only reflecting the patients who underwent an operation and had a persistent high suspicion for appendicitis despite the negative or inconclusive results of the imaging.

While factors such as the ASU, CT use and restricted theatre access have been identified as affecting patient outcomes and length of stay, other unidentified factors could have played a part as well.

3.5 Conclusion

Over a decade from 2004 to 2014, the NAR at Wellington Hospital was 22.2%. The use of routine imaging would likely reduce the NAR in our hospital, but there are significant downsides to it, including increased demand on already strained hospital resources, which may result in significant delays and potentially compromise patient safety. The question remains what NAR is considered acceptable while using selective imaging.

Chapter 4: Appropriateness of CT scans for patients with non-traumatic acute abdominal pain.

4.1 Introduction

From the previous two chapters it is clear that the use of CT scans, to aid the diagnostic process for a patient presenting with acute abdominal pain to our institution, has significantly increased over the last decade(103, 126). An increasing proportion of these scans show no acute or new pathology that can explain the patient's symptoms(103). Furthermore, it seems that the increased use of this diagnostic tool has not resulted in a simultaneous reduction of the NAR(126). These findings are in concordance with results from studies in similar healthcare systems to ours(3, 41, 42).

CT scans are associated with a high diagnostic accuracy with a sensitivity and specificity of approximately 90-95%.(39, 43, 44, 99, 127). However, to date there is no convincing evidence that this increase in diagnostic accuracy also leads to a reduction in final outcomes such as length of stay, complications and mortality for patients presenting with acute abdominal pain(3, 44, 46). Furthermore, the use of this diagnostic tool also has downsides. Imaging can lead to higher costs and delay in diagnosis due to long waiting times to obtain a CT scan(46). Other risks include contrast allergies, contrast induced nephropathy and ionizing radiation exposure(119, 128). Ensuring appropriate and not excessive use of CT scans in this patient population is therefore a priority.

The aim of this study was to evaluate our institutions CT scan requests for patients presenting with acute and new abdominal pain and to determine how many of these scans were considered clinically indicated.

4.2 Methods

Inclusion criteria

Data were collected for a hundred consecutive CT scans meeting inclusion criteria for inpatients in the general surgical department starting from the 1st of January 2016. Patients were included if they had a CT scan for new abdominal pain within two days of their admission. Patients who had post-operative scans (all scans for patients within 30 days from their operation or for pathology directly associated to an operation within 90 days), pain for more than seven days before admission or were admitted because of trauma, were excluded.

Case summaries and data collection

A summary was written about the patient's initial presentation. The summary included: age, gender, relevant medical history, duration of symptoms, location of pain, accompanying symptoms (e.g. nausea, vomiting and bowel motions), findings on examination (including localised pain or presence of peritonism), any abnormal blood results and abnormal findings on plain X-ray. These summaries were generated from ED notes, admission notes, CT scan request forms and admission blood results. Summaries were written and reviewed by a consultant general surgeon.

Five consultant general surgeons and five consultant radiologists were asked to independently review the hundred selected cases. On the basis of the patient summary, the reviewer was asked whether a CT scan was indicated and if yes whether this scan was urgent (perform within 12 hours) or non-urgent. If the reviewer thought the CT scan was not indicated, they were asked whether another imaging modality was more appropriate or not. Alternatively, they could state whether they required more clinical information in order to make any decision. An example of a patient summary and the questions asked is shown in figure 4.1.
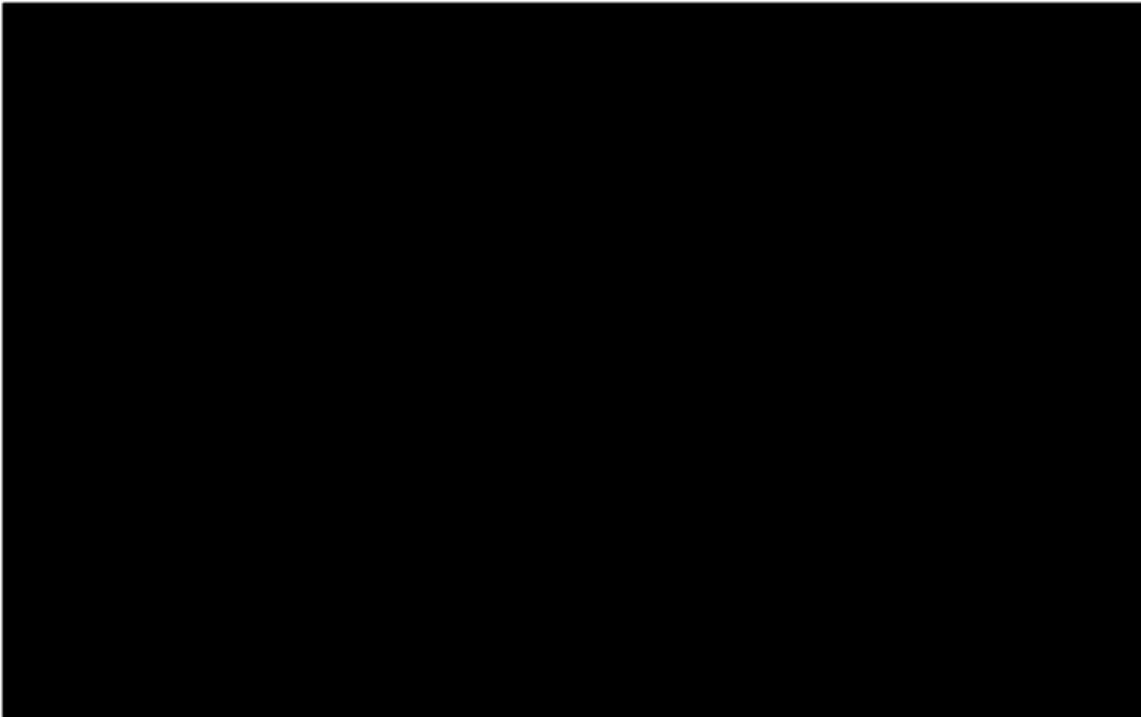
Figure 4.1 Example of a case summary

Decisions on whether the scan was indicated or not were based on the clinicians experience. No appropriateness criteria (for example the appropriateness criteria of the American College of Radiologists(129)) were used, because it was considered that these were not applicable to all cases.

The results were analysed by two different methods. Firstly, the individual answers given by each participating consultant were evaluated. Secondly, each case (representing a patient who had an abdominal CT scan) was grouped according to the majority decision. In the latter analysis the cases were divided into three groups. Group 1 where five or more consultants agreed that there was no indication for the CT scan, group 2 where consultants opinion was evenly divided about the indication of a scan or group 3 where five of more consultants agreed that the CT scan was indicated.

The patient characteristics (gender and age), relevant medical history, findings on examination and blood results (WCC and CRP) were compared between the three groups.

The outcomes of the scans and the final diagnosis (at the time of discharge) were collected and compared with the decisions about the indication of the scan of the experts. A scan was considered negative for acute pathology when no pathology on the scan could be demonstrated that could explain the patient's symptoms.

Ethical approval

See chapter 2.2.

Statistical analysis

The data were analysed using the same statistical principles as explained in the methods section of chapter 2. For non-parametric data median and range (not IQR) was used. Additionally, reliability analysis was used to calculate the Cronbach's Alpha to determine the level of agreement among the specialists.

4.3 Results

A hundred cases were selected out of the first 314 abdominal CT scans that were performed from the January 2016 to May 2016. Cases were excluded because they were requested for patients that had a complication after an operation, had a scan related to a recent trauma or had pain for more than seven days.

Of the hundred case summaries reviewed, the specialists reported that the CT scans were not indicated in a median of 21% (range 12-39%), more information was required in a median of 16% (range 0-41.0%) and in a median of 58% (range 37-88%) the CT scan was indicated (table 4.1). When the CT scan was indicated, a median of 15% (range 3-49%) were considered urgent and a median of 33.5% (range 16-85%) were considered non-urgent (p=0.015). Two out of the ten consultants opted for an outpatient scan, one consultant selected this option twice, the other 5 times. Of the CT scans that were not indicated another imaging modality was thought to be more appropriate in a median of 66% (range 35-75%).

Table 4.1 Specialist answers

	Surgeons					Radiologists				
	1	2	3	4	5	1	2	3	4	5
Not indicated	**20**	**21**	**36**	**31**	**12**	**39**	**22**	**12**	**18**	**53**
Other modality	7	13	26	20	8	23	12	9	13	36
Not indicated	13	8	10	11	4	16	10	3	5	17
Indicated	**72**	**65**	**48**	**52**	**58**	**52**	**37**	**88**	**65**	**47**
Urgent	49	22	10	36	10	26	12	3	4	18
Non-urgent	23	43	38	16	48	26	25	85	61	29
More information	**8**	**14**	**16**	**17**	**30**	**9**	**41**	**0**	**17**	**0**

Summary of individual answers per specialist adding up to 100 cases.

When results were analysed based on the majority decisions group 1 (CT not indicated) comprised 20% of the cases, group 2 (CT maybe indicated) 13% and group 3 (CT indicated) the remaining 67%. Patients in group 3, were statistically significantly older (p=0.003), were more likely to have peritonism or a palpable mass on examination (p=0.017) and were more likely to have a raised CRP (p=0.050), compared to the patients in the other two groups. Gender, a relevant medical history and a raised WCC were not associated with the indication for CT scan (table 4.2).

Table 4.2 Group characteristics

	CT not indicated (N=20)	CT maybe indicated (N=13)	CT indicated (N=67)	p value
Age (mean, [SD])	48 [19]	56 [20]	62 [14]	0.003*
Gender (%)				
Male	11 (55%)	5 (39%)	33 (49%)	0.648
Relevant medical history (%)				
Yes	7 (35%)	9 (69%)	40 (60%)	0.087
Examination (%)				
Peritonism or mass	1 (5%)	2 (15%)	20 (30%)	0.017*
Raised WCC (>12.0 x 10^9/L)	9 (45%)	1 (8%)	26 (39%)	0.620
Raised CRP (>25 mg/L)	7 (35%)	5 (39%)	38 (57%)	0.050*

CT; Computed Tomography, WCC; White Cell Count (10^9/L), CRP; C-Reactive Protein (mg/L).
* Significant findings (p ≤0.05)

The cases in group 2 were more commonly rated as requiring additional information to make a decision (median of 3 consultants saying this per case) compared to those in groups 1 and 3 (median of 1 consultant saying this per case in each of these groups, p=0.001).

New pathology was found in 55.0% in group 1, 76.9% in group 2 and 83.6% in group 3 (p=0.029). Of the twenty patients in group 1, where a CT scan was considered not indicated by the ten specialists, nine (45.0%) had no pathology on the scan that could explain the patients symptoms. Eleven patients (55.0%) did have new pathology on the scan, five had cholecystitis, three had uncomplicated diverticulitis, one had right sided colitis, one had a partial small bowel obstruction and the last patient had appendicitis. All of them, except the patient with appendicitis, were treated conservatively. The appendicitis case, had an atypical presentation with inflammatory markers (WCC and CRP) within normal range and was of older age (51 years old).

The calculated value of agreement (Cronbach's Alpha) between the ten consultant specialists about the indication of the CT scan was 0.704.

4.4 Discussion

The results of this study suggests that a significant proportion of CT scans in patients with acute abdominal pain are not clinically indicated or are being performed prior to adequate clinical workup.

One fifth of the CT scans were considered not indicated when analysed by the individual specialist as well as when grouping the specialists to obtain a majority decision per individual case. Eleven patients (55.0%) in this group, did however have new pathology on the scan. All, except one patient, had relatively benign diagnoses and were treated conservatively. With a more thorough work-up these scans might not have been indicated. Five patients had cholecystitis which correlates with the results that in a median of 66% of the cases where the specialists though a CT was not indicated, but another imaging modality was considered more appropriate (usually an US). The reason why a CT scan was requested and not an US, is difficult to explain from these results. It is possible that US is perceived as more difficult to obtain, so a CT scan is requested instead. Another reason might be that due to body habitus a CT scan was preferred over an US(130).

When the CT scan was considered indicated in the majority of the cases the scan was considered non-urgent (p=0.015). Only two consultants selected the option of requesting an outpatient instead of an inpatient scan in only a couple of cases. This may be because an outpatient scan, in our institution, usually results in a significant diagnostic delay (weeks to months).

Specialists were more likely to agree about the indication for a CT scan when the patients were older, had peritonism or a mass found on examination or when they had a raised CRP. Significantly more specialists indicated that they required more information for patients in group 2 (CT maybe indicated), before they could make a decision. This result implies that patients in group 2 required a more intensive work up prior to requesting the scan.

There are a number of studies that have looked at routine imaging and the diagnostic accuracy for patients presenting with acute abdominal pain to the ED. These studies show that routine imaging is associated with approximately forty percent of the scans being negative for acute pathology(39, 130-132). A

recent study, in a comparable health care system to ours, showed that routine imaging is associated with increased cost and longer length of hospital stay compared to selective imaging at all ages. They concluded that routine CT cannot be recommended for unselected patients with acute abdominal pain(46). This is also supported by the world wide initiative, 'Choosing Wisely', which promotes the thoughtful use of hospital resources particularly in the ED. Despite this introduction, specialists struggle with the uncertainty and patient expectations, even though the evidence supports a higher risk tolerance and a less defensive approach(133).

There was a good level of agreement amongst the ten specialists from the two specialties. This finding supports that both departments should further investigate the appropriateness of the CT scan requests in our hospital. The authors are aiming to do this by introducing a diagnostic pathway for patients presenting with abdominal pain to the ED. Part of this pathway is an improved and standardised work up of the patients, a senior review and a verbal discussion with the on call radiologists prior to requesting an abdominal CT scan.

A limitation of the design of the study was that case summaries were made retrospectively on the basis of the available documentation from ED, the admission, laboratory results and the CT request form. Information might have been misinterpreted or missed due to this design. The consultants were asked to review a hundred cases, this number was chosen empirically by the authors as the volume enabled comparison both between cases and between the consultants and represented a reasonable representation of the clinical workload.

4.5 Conclusion

Both radiology and general surgery consultants agreed that there was no indication for an abdominal CT scan in one fifth of all requests. In 66% of these patients another imaging modality (most often US) was considered to be more appropriate. Based on these results it seems that a more critical review may be required prior to ordering CT scans for patients presenting with acute abdominal pain, particularly in younger patients, those without peritonism or elevated CRP results. This will reduce the number of unnecessary scans and thereby reduce patient radiation, waiting times and hospital costs.

In a prospective follow up study (chapter 8) all radiology requests, especially for patients with a non-surgical diagnosis, needed to be reviewed by a senior registrar or consultant in order to optimise the use of this diagnostic tool.

Chapter 5: Patients requiring an acute operation, where are the delays in the process?

5.1 Introduction

An effective and efficient surgical service is critical to any healthcare system. Recent data on over one million hospital admissions in New Zealand found that almost a quarter of all admissions under general surgery require an acute operation(9). These cover a broad spectrum of acuity which includes the relatively minor, e.g. incision and drainage of an abscess, to life saving interventions such as a trauma laparotomy. Therefore, a prioritising system has been introduced to stratify emergency procedures based on urgency(134, 135).

In chapter 2 and 3 of this thesis we found that, for a patient presenting with an acute surgical problem requiring an operation, the duration between presentation and arriving in theatre has increased over the last decade(103, 126).

Two time intervals in which delays may occur have been identified. The time between a patient presenting to the hospital and being booked for theatre may be subject to delays in obtaining diagnostic tests i.e. a diagnostic delay. The time between booking a patient for theatre and actually getting them to theatre may suffer from logistical delays(136-140). Delays from presentation to theatre have been associated with higher rates of post-operative complications, increased mortality risks and increased length of stay(137-139). Furthermore, patient expectations and comfort can also be compromised by treatment not occurring in a timely manner.

The aim of this study was to evaluate the patient's progress from acute presentation to arrival in the operating theatre and to identify where delays occur.

5.2 Methods

A retrospective clinical study was performed at Wellington Regional Hospital.

Inclusion criteria

All patients that underwent emergency surgery under the general surgery service between 1st of July 2016 and 31st of May 2017 were included. Exclusion criteria were patients under the age of 16 and those undergoing elective surgery.

Data collection

Prospectively collected data were obtained from the theatre database and the clinical records including the radiology database. Times and dates of clinical presentation, imaging, theatre and discharge were obtained from these databases in order to calculate the intervals between them.

The presentation time was defined as the time the patient was first registered in the ED. In our institution all patients, even patients referred from a GP, register in the ED first.

Time of imaging was the time imaging was performed. Preliminary imaging results are generally available soon after the imaging is performed and are given verbally to the referring doctor.

Theatre times were divided as time in theatre, which was the moment the patient enters the operating room and time of incision which was first knife to skin contact.

Patients had a minimum follow-up of ninety days, morbidity and mortality data were collected. Complications were defined as unexpected adverse events (e.g. pneumonia, wound infection, atrial fibrillation (AF)) during hospital stay or within ninety days from discharge requiring re-admission or medical intervention in ED.

All cases were booked via an electronic acute theatre booking form. A booking category was assigned to each case: category 1 for immediate operation, category 2 within two hours, category 3 within six hours and category 4 within 24 hours from the time of submitting the electronic booking form. In this analysis category 1 and category 2 were combined into one group, as both are relatively uncommon.

Logistic and diagnostic delay

The time interval from when a patient presented to the ED to when they were booked for theatre was calculated. A diagnostic delay was defined as any patient waiting longer than six hours until they were booked for their operation. In the literature, there is no consistent definition of diagnostic delay. We chose six hours because of previous studies performed in the ED setting showing that waiting times greater than 6 hours were associated with poorer outcomes(60-62). If the number of hours between booking a patient for theatre and the time the patient arrived in theatre exceeded the previously described target time of the category the patient was booked in, this was defined as a logistic delay.

Abdominal operation

A sub-analysis was performed for patients undergoing an acute operation for acute abdominal pain. Hernia operations and trauma operations (similar methodology as in previous chapters) were excluded in this analysis as their diagnostic process generally differs from other acute abdominal pain presentations. The frequency of diagnostic and logistic delays were compared between patients undergoing an operation for acute abdominal pain versus patients undergoing an acute operation related to another general surgical complaint.

Statistical analysis

The data were analysed using the same statistical principles as explained in the methods section of chapter 2. Additionally, for non-parametric data the Mann-Whitney U test between two groups and the Kruskal-Wallis test between three groups. Univariate analysis was first performed using a Chi square tests to determine which variables were significantly associated with a diagnostic delay. To identify independent predictors of this delay, variables identified as significant in univariate analysis were subsequently included in a stepwise logistic regression analysis.

5.3 Results

A total of 683 patients had an acute general surgical operation between 1 July 2016 and 31 May 2017. A total of 91 (13.3%) patients were booked as category 1&2, 395 (57.8%) patients were booked as category 3 and 197 (28.8%) were booked as category 4.

Patients in the category 1&2 group were significantly older compared to the other groups (p<0.001), were more likely to be referred from the ED (p<0.001), were more likely to have co-morbidities at the time of presentation (p<0.001) and had a higher ASA score (p<0.001), (table 5.1). There was no statistical difference for gender and ethnicity between the three groups. Operation characteristics are shown in table 5.2.

Table 5.1. Patient characteristics and time course during admission.

	Category 1&2 N=91	Category 3 N=395	Category 4 N=197	p value
Age (years)	57.0 (40-75)	34.0 (23-53)	36.0 (25-50.5)	<0.001*
Gender (male (%))	49 (53.8%)	182 (46.1%)	100 (50.8%)	0.305
Referred (ED (%))	66 (73.3%)	185 (47.1%)	81 (41.1%)	<0.001*
Co-morbidities (yes (%))	60 (65.9%)	132 (33.4%)	75 (38.1%)	<0.001*
ASA score	2 (2-3)	2 (1-2)	1 (1-2)	<0.001*
Imaging (yes (%))	57 (62.6%)	144 (36.5%)	32 (16.2%)	<0.001*
Presentation to imaging	8.5 (4.6-14-7)	9.6 (5.1-16.1)	12.9 (6.7-18.7)	0.077
Presentation to booking	6.4 (3.4-16.2)	8.4 (3.8-16.4)	4.5 (2.7-14.9)	0.003*
Booking to theatre	1.5 (1.0-2.6)	5.0 (2.5-10.4)	6.7 (3.5-15.9)	<0.001*
Theatre to incision	0.6 (0.4-0.8)	0.4 (0.3-0.5)	0.3 (0.3-0.4)	<0.001*
Presentation to incision	8.9 (5.2-18.0)	18.0 (11.1-25.1)	17.6 (8.7-24.9)	<0.001*
Length of hospital stay	6.1 (3.6-10.6)	2.1 (1.7-3.7)	1.6 (1.0-2.4)	<0.001*

Median (IQR) for non-parametric data. Times are in hours, except for length of hospital stay which is in days. ED; emergency department, ASA; American Society of Anaesthesiologists. * Significant findings (p ≤0.05)

Table 5.2. Surgical procedures for the different booking categories

	Category 1&2 N=91	Category 3 N=395	Category 4 N=197	Total N=683
Skin procedure/abscess	9 (9.9%)	51 (12.9%)	158 (80.2%)	**218 (31.9%)**
Appendicectomy	14 (15.4%)	265 (67.1%)	2 (1.0%)	**281 (41.1%)**
Cholecystectomy	1 (1.1%)	11 (2.8%)	18 (9.1%)	**30 (4.4%)**
Laparotomy	36 (39.6%)	33 (8.4%)	11 (5.6%)	**80 (11.7%)**
Laparoscopy	4 (4.4%)	4 (1.0%)	0	**8 (1.2%)**
Hernia operation	19 (20.9%)	28 (7.1%)	8 (4.1%)	**55 (8.1%)**
Trauma operation	8 (8.8%)	3 (0.8%)	0	**11 (1.6%)**

Diagnostic delay

In total 376 (55.1%) of the patients waited longer than six hours (diagnostic delay) from when they presented to hospital until they were booked for their operation. Patients were more likely to have a diagnostic delay when they were booked for theatre as a category 3, compared to the other booking categories (60.9% for category 3, 55.1% for category 1&2 and 42.9% for category 4, p<0.001) (table 5.3).

Imaging was requested during the diagnostic period in 34.1% of patients and was most commonly a CT scan (73%). The median time from presentation to imaging was 9.7 hours (5.1-16.0 hours). However, the median time from requesting imaging to imaging being performed was 2.8 hours (1.4-4.5 hours), thus the majority of the presentation to imaging time was prior to imaging being requested. A diagnostic delay was observed in 82% of those with imaging, compared to 41% of those who did not have imaging (p<0.001). There was a difference in the proportion of patients in each category undergoing imaging (table 5.1).

Four hundred and thirteen (60.5%) patients presented during the day shift (8am - 6pm), 155 (22.7%) presented during the evening shift (6 - 11pm) and 115 (16.8%) presented during the night shift (11pm - 8am). Patients that presented during the day shift were significantly less likely to have a diagnostic delay (45.8% day shift vs. 66.9% evening and 71.3% night shift, p<0.001). The proportion of patients booked as a category 1&2 across the three shifts differed significantly, with 9.7% of the patients booked in these categories during the day, 12.9% during the evening shift and 27.0% during the night shift (p<0.001). The use of imaging also differed by time of presentation, with a higher proportion of the night shift presentations having imaging compared to patients that presented during the other two shifts (52.2% night shift vs 29.3% day shift and 33.5% evening shift, p<0.001). Time from presentation to booking did not differ significantly between patients that presented during weekdays compared to patients that presented during the weekend 7.2 (3.4-16.6) vs. 6.1 (3.2-13.9) hours respectively, p=0.383.

In multivariate analysis, including booking category, time of presentation, referrer and imaging, only imaging prior to surgery and referral via the ED were significantly associated with a diagnostic delay (p<0.001 for both).

Table 5.3 Delays to theatre	**Yes (%)**	**No (%)**	**p value**
Diagnostic delay	55.1	44.9	<0.001*
Category			<0.001*
1&2	55.1	44.9	
3	60.9	29.1	
4	42.9	57.1	
Imaging (yes)	82.0	41.0	<0.001*
Time presented			<0.001*
Day shift	45.8	54.2	
Evening shift	66.9	33.1	
Night shift	71.3	28.7	
Referrer (ED)	67.5	32.5	<0.001*
Logistic delay	31.0	69.0	<0.001*
Category			<0.001*
1&2	30.6	69.4	
3	41.8	58.2	
4	5.4	94.6	
Time of booking			<0.001*
Day shift	41.4	58.6	
Evening shift	53.4	46.6	
Night shift	25.1	74.9	
In univariate analysis. * Significant findings (p ≤0.05)			

Logistic delay

Overall 31.0% of the patients did not have their operation within the booking category timeframe. This was 30.6% for the patients booked as category 1&2, 41.8% for the patients booked as category 3 and 5.4% for the patients booked as category 4 (p<0.001), (table 5.3)
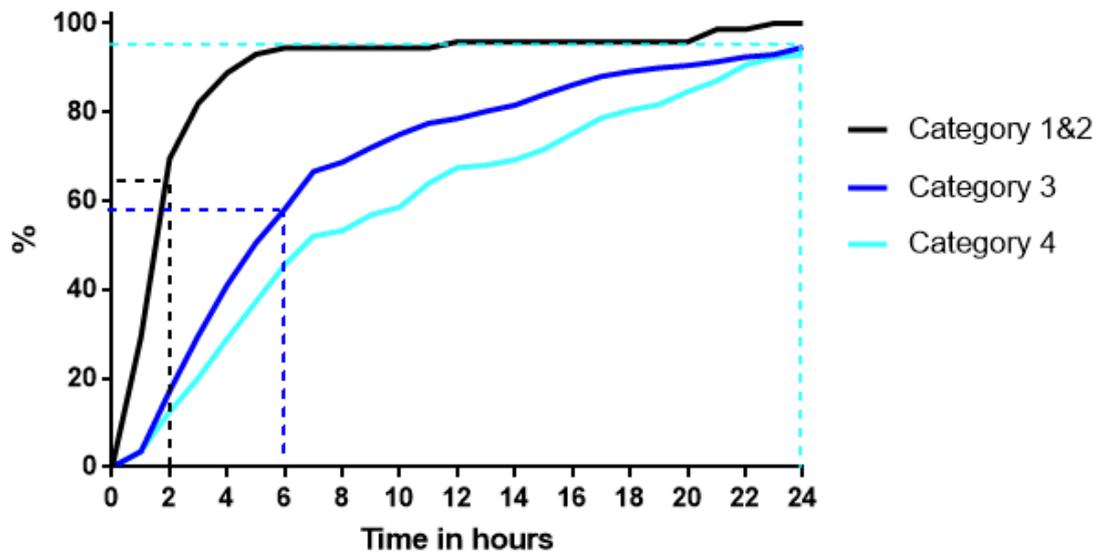
Figure 5.1 Time from booking to arriving in theatre plotted per booking category. The dotted lines mark on the X-axis the time a patient should be in theatre according to the booking category and on the Y-axis the proportion of patients that achieved each categories time target.

Table 5.4 Cumulative count of patients per prioritising category from booking to first incision

	Category 1&2 N=91	Category 3 N=395	Category 4 N=197	Total N=683
< 2 hours	38 (41.8%)	45 (11.4%)	17 (8.6%)	100 (14.6%)
< 6 hours	83 (91.2%)	215 (54.4%)	81 (41.1%)	379 (55.5%)
< 12 hours	84 (92.3%)	308 (78.0%)	127 (64.5%)	519 (76.0%)
< 24 hours	90 (98.9%)	373 (94.4%)	183 (92.9%)	646 (94.6%)
Cumulative counts and percentages per column				

Figure 5.1 and table 5.4 show the time from booking in hours and the arrival in theatre per booking category.

A logistic delay occurred significantly more frequently when the patient was booked for theatre during the evening or night shifts compared to patients that were booked during the day (41.4% and 53.4% vs 25.1% respectively, p<0.001). No other patient characteristics were significantly associated with a logistic delay (table 5.3).

Abdominal operation

In total 399 (58.4%) patients had an abdominal operation. An appendicectomy was performed for 281 (70.4%) patients, a laparotomy for 80 (20.1%) patients, a cholecystectomy for 30 (7.5%) patients and a laparoscopy for 8 (2.0%) patients. Details about booking category and occurrence of delays are displayed in table 5.5.

Table 5.5 Comparison between acute abdominal operation and acute other general surgery operations

	Operation for acute abdominal pain		
	Yes (%)	No (%)	p value
	399 (58.4)	284 (41.6)	<0.001*
Category			<0.001*
1&2	13.8	12.7	
3	78.4	28.9	
4	7.8	58.5	
Diagnostic delay (yes)	66.5	38.6	<0.001*
Logistic delay (yes)	37.2	21.6	0.032
In multivariate analysis. * Significant findings (p ≤0.05)			

Morbidity and mortality

In total 100(14.6%) patients had a complication. Pneumonia was the most common postoperative complication (37.0%), other complications included; prolonged postoperative ileus, defined as: not opened bowels within 5 days after surgery (23.0%), wound infection (16.0%), cardiology complications (mainly AF) (17.0%) and other (7.0%). The complication rate was significantly higher for patients booked as a category 1&2, 36.3% compared to 11.1% for category 3 and 11.7% for category 4 (p<0.001) (table 5.6).

Table 5.6 Complications

	Category 1&2 N=91	Category 3 N=395	Category 4 N=197	Total N=683
Pneumonia	12	14	11	37
Ileus	6	12	5	23
Wound infection	1	9	6	16
Cardiology	9	8	0	17
Other[#]	5	1	1	7
Total	**33 (36.3%)**	**44 (11.1%)**	**23 (11.7%)**	**100 (14.6%)**

includes: intra-abdominal collections, iatrogenic complications related to the operation, etc.

The complication rate was significantly higher for patients who had a diagnostic delay compared to patients that did not (17.2% vs 10.0%, p=0.009). Amongst the three categories, a significant difference in complication rate between patients that did or did not have a diagnostic delay was only evident for patients booked as a category 3 (p=0.009 compared to p=0.239 for category 1&2 and p=0.243 for category 4). The complication rate did not differ for patients that had a logistic delay to theatre versus patients that were operated within the time frame of the booking category (14.0% vs 9.5%, p=0.120).

Seven patients died during the study period, six during their stay in hospital and one patient was re-admitted with a complication and died as a consequence of this. Of these five were operated on within the timeframe of the category in which they were booked for theatre and two had a logistic delay.

5.4 Discussion

The results demonstrate that diagnostic and logistical delays for patients booked for an acute operation are common. Imaging (US or CT) prior to theatre was associated with a diagnostic delay, while patients booked as a category 3 (surgery within 6 hours) and booking a patient for theatre out of hours were associated with logistic delays.

Diagnostic delay

Patients who required imaging had a significantly longer time from presentation to booking. Most of this delay is between patient presentation and requesting the imaging, not in obtaining the tests or in interpreting the results. This implies that this delay is likely due to diagnostic uncertainty that eventually leads to requesting these diagnostic tests.

Patients that were booked as a category 3 had the longest time between presentation and booking (8.4 hours), they also make up the majority of cases (57.8%). There are a number of possible reasons that the time from presentation to booking is particularly long within this group. One explanation is that these patients may have been observed on the ward for a number of hours until their clinical presentation became clear. Another explanation is that these patients were less urgent and therefore there was a delay in assessing these patients by ED doctors, by the surgical team or possibly both. A reason why the latter explanation may not applicable to patients booked as a category 4, is that their pathology is usually reasonably straight forward e.g. an abscess that requires drainage and for these patients a senior review is generally not required. However, these possible explanations are speculative and further work is needed to clarify the causes of diagnostic delay.

Logistic delay

Overall, 31.0% of the patients included in this study had a logistic delay. A recent study in a comparable health care system to ours included over 15,000 patients who required an acute operation and found that 18.6% of their patients

had an operation outside the categorised timeframe. This was associated with increased risks for in-hospital morbidity and mortality, increased costs and increased length of stay(137). This implies that the logistic delays in our institution are worrying and that changes in theatre access are required to address this problem.

Patients booked as a category 3 had the greatest probability of not having an operation in the designated timeframe, with 41.8% of cases falling outside the proposed timeframe. It was not possible to isolate any specific factors which led to this delay. It is possible that as these cases make up such a large proportion of the caseload (57.8%) that they are straining acute theatre capacity which is unable to meet current demand(137). Furthermore, cases booked as a category 3 are generally not performed between 11pm and 7am which may also contribute to the delay. This is in line with the findings from a recent publication where they demonstrated that the most common cause for a logistic delay is a case of greater urgency taking priority(126).

Abdominal pain

A diagnostic and a logistic delay occurred significantly more frequently in patients that had an operation for acute abdominal pain compared to patients who had an acute operation for another type of presentation (e.g. abscess, hernia, etc). Especially the difference in occurrence of a diagnostic delay is remarkable. This is in concurrence with previous studies highlighting the diagnostic difficulties for patients presenting with abdominal pain(32, 103, 141).

Morbidity and mortality

This study showed that patients who had a diagnostic delay were more likely to have a complication compared to patients that did not. In looking at this relationship by category, the relationship between diagnostic delay and complications was only significant in category 3. This suggests that diagnostic delays associated with stabilisation of critically unwell patients prior to booking are unlikely to cause the observed association. No significant differences in

complication rates were found between patients that had a logistic delay and patients that did not. Also, no differences in mortality rates were observed. It is important to note that this study was not powered to detect the relationship between delays and adverse clinical outcomes, and that these have been consistently observed in larger studies(137).

Limitations

Due to the design of the study not all reasons for both diagnostic and logistic delays could be fully assessed. Furthermore, this study was underpowered to observe a difference in length of stay and morbidity for patients who have a logistic delay as previously discussed.

The decision to identify a diagnostic delay as longer than 6 hours between presentation and booking is arbitrary, but based on previous literature as it is showing poorer outcomes for patients in ED waiting longer than 6 hours for their assessment(60-62). Significantly more patients with a diagnostic delay were referred via the ED compared to the GP or another in-hospital service (e.g. general medicine). However their delay might be multifactorial and it is not possible to define this any further from our database.

To identify specific factors resulting in both a diagnostic and a logistic delay, a large prospective study needs to be designed.

5.5 Conclusion

This study has shown that there are significant delays occurring in the process of getting an acute surgical patient to theatre. The diagnostic delay is most evident for a patient requiring imaging prior to their operation. A logistic delay occurred in close to a third of the patients, but was most evident for patients booked as a category 3.

Delays (both diagnostic and logistic) are associated with poorer outcomes for the patient. Therefore, both have to be addressed to improve quality of care for the acute surgical patient. Future research should be aimed at identifying the specific factors causing a diagnostic delay. To address the logistic delay we are advocating the necessity of a full day general surgery acute theatre list.

Section 2

Evaluating the current evidence of how patients who present with acute abdominal pain to the hospital are assessed.

Chapter 6: Systematic review of diagnostic pathways for patients presenting with acute abdominal pain

6.1 Introduction

The previous chapters have shown that diagnosing patients who present with abdominal pain to the ED is a challenge. It has been identified that the number of presentations and admissions has significantly increased over the last decade and that an increasing proportion of the patients are presenting with non-surgical problems. Furthermore, it has been shown that the use of CT scans to aid the diagnostic process has increased (chapter 2), this increase has not been reflected in improved diagnoses especially with respect to appendicitis (chapter 3), approximately 20% of these scans are not indicated (chapter 4) and patients requiring an acute operation have increasing times from presentation to theatre (chapter 2 and 3). This is a multifactorial delay (diagnostic and logistic), but it has a significant impact on patient outcomes, including: length of hospital stay, morbidity and mortality (chapter 5).

Optimising the assessment process for this patient group would ideally result in improved use of hospital resources, faster differentiation between patients who are unwell and patients who are well or have a non-surgical diagnosis and improved final outcomes (length of stay, morbidity and mortality). A diagnostic pathway might be a useful tool in trying to achieve this.

Clinical pathways can reduce inter-clinician decision variation, improve quality of care, and maximize the outcomes for specific groups of patients(142, 143). The European Pathways Association (EPA) developed five criteria to define a clinical pathway: (1) an explicit statement of the goals and key elements of care based on evidence, best practice, and patients' expectations and their characteristics; (2) the facilitation of the communication among the team members and with patients and families; (3) the coordination of the care process by coordinating the roles and sequencing the activities of the multidisciplinary care team, the patients and their relatives; (4) the

documentation, monitoring, and evaluation of variances and outcomes, and (5) the identification of the appropriate resources(144).

The aim of this systematic review was to identify the current evidence for diagnostic pathways for patients presenting with abdominal pain and their effect on final outcomes such as morbidity, mortality and length of stay.

6.2 Methods

A systematic review was performed using Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) to identify, select and critically appraise relevant research while minimizing bias(145).

Search strategy

An extensive literature search of the Medline, Cochrane and EMBASE databases from 1st of January 2000 to 31st of January 2017 was performed. The MeSH term 'acute abdomen' OR the keywords 'abdominal pain' OR acute abdomen were used. The search was limited to papers including adults and articles written in English, Spanish, French, German or Dutch. Titles and abstracts were examined to determine the relevance of the information. Full texts were obtained for the studies that were relevant on the basis of title and abstract. These were then reviewed and a final inclusion selection was made.

Study selection

All studies describing a pathway for diagnosing abdominal pain or a specific diagnosis that causes abdominal pain (e.g. appendicitis or diverticulitis) and that fulfilled at least two of the three EPA criteria for a clinical pathway, were included(144).

Data extraction

The following information was extracted from each study: first author's last name; publication year; number of patients; study design; the described pathway and use of additional imaging and final outcomes (complications, mortality, length of stay) and if the pathway was prospectively tested by the authors of the included study. For the use of imaging, two categories were used to describe the frequency of the use of this modality, selective or routine. If specific criteria for the use of imaging were described, this was described as

selective use. While routine meant that nearly all patients underwent some form of imaging.

Two researchers screened each study and extracted data independently using standard forms, a third was consulted to reach consensus in case of disagreement.

Quality assessment

In observation of PRISMA guidelines, the methodological quality of the studies was assessed using the Methodological Index for Non-Randomized Studies (MINORS) as the included studies were all of different design(146, 147). The maximum score for a non-comparative study is sixteen and for a comparative study, twenty-four. The Oxford Centre for Evidence-based Medicine, Levels of Evidence was also used(148). Quality assessment was independently performed by two researchers and consensus was reached by discussion and if considered necessary a third was consulted. In order to assess the complexity of the included pathways, all of the three involved researchers were asked to rank the pathways included as; easy, medium or hard to follow and the number of decision and end points in each pathway were calculated to give each a score. The ranking of the pathways were then compared to these scores.

6.3 Results

Study selection

A total of 1839 citations were identified using our search criteria in Embase and 3953 in Medline. Duplicates were removed leaving the total at 4655 articles. The title and abstracts of these articles were reviewed, the majority of the studies were excluded as they did not mention a diagnostic process for patients with abdominal pain in either the title or the abstract. The full text was obtained for 136 articles, from these a further 126 articles were excluded as they did not describe a pathway as described by the EPA criteria. This led to a total of ten papers included in this review (figure 6.1, table 6.1).
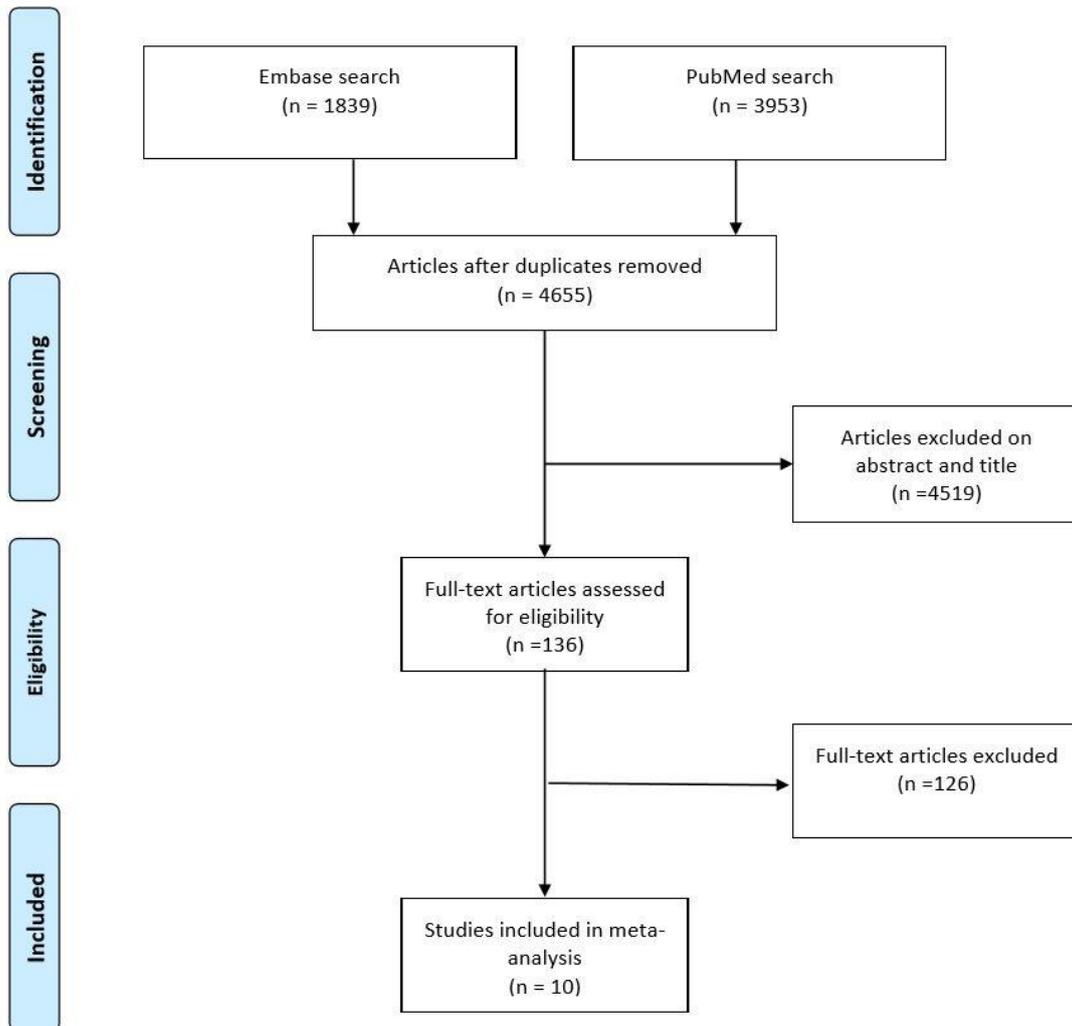
Figure 6.1 Flow diagram of included studies

Table 6.1 Included studies

	Year publication	Study type	Level of evidence	MINORS
Ng et al.	2002	RCT	1b	n/a
Lameris et al.	2009	Prospective cohort	1b	16
Scott et al.	2015	Prospective cohort	1b	14
Toorenvliet et al.	2010	Prospective cohort	1b	11
Majewski et al.	2000	Prospective cohort	3b	11
Gans et al.	2014	Literature review	5	n/a
Karul et al.	2013	Literature review	5	n/a
Lyon et al.	2006	Literature review	5	n/a
Trentzsch et al.	2011	Literature review	5	n/a
Mayumi et al.	2015	Literature review	5	n/a

RCT; Randomised Controlled Trial, n/a; not applicable

Table 6.2 Summary proposed pathways

	Assessment specifics	Role plain X ray	Role of US	Role of CT	Complexity described pathway
Ng et al.	Standard	Selective	-	Routine	Medium
Lameris et al.	Urgent vs non-urgent	Selective	Routine	Selective	n/a
Scott et al.	Low/intermediate/high risk appendicitis	-	Selective	Selective	Low
Toorenvliet et al.	Suspected appendicitis	-	Routine	Selective	Low
Majewski et al.	Standard	Routine	Routine	Selective	Medium
Gans et al.	Urgent vs non-urgent	Selective	Routine	Selective	High
Karul et al.	Suspected appendicitis	-	Routine	Selective	Medium
Lyon et al.	Standard, focussed on elderly patient	Routine	Selective	Selective	Medium
Trentzsch et al.	Subdivided per probable diagnosis	Selective	Routine	Selective	High
Mayumi et al.	Urgent vs non-urgent	Selective	Selective	Routine	Medium

n/a; not applicable

Characteristics of the included studies

Five studies designed a pathway based on the results of a prospective study(39, 44, 57, 100, 116). A summary of these studies including patient characteristics, diagnostic proposal, diagnostic accuracy, complications, mortality and LOS of the included patients is described in table 6.3.

One of these was a randomised controlled trial. In this study, Ng et al. (44), compared routine versus selective CT scans for patients with acute abdominal pain. They found that routine CT scanning was associated with significantly less missed serious diagnoses compared to the selective imaging group (13% vs 4%, p=0.014). In the selective imaging group only 11.1% had a CT scan. Length of stay was 5.3 days for the routine imaging group versus 6.4 days for the selective imaging group (p=0.17). The authors therefore recommend routine CT scans for patients presenting with acute abdominal pain.

Two prospective cohort studies examined pathways for the management of patients with suspected appendicitis(100, 116). Toorenvliet et al. (116) included 802 patients with abdominal pain but mainly focused on patients with suspected appendicitis. Their pathway included routine US and selective CT scanning (17.9%). Patients with an unclear diagnosis, were re-evaluated the next day and if considered necessary re-imaged. Their main outcome was the negative appendicectomy rate, which was 3.3%. They conclude that routine US scan, use of selective CT scanning and re-assessing of the patient if the diagnosis is unclear within 24 hours is associated with high diagnostic accuracy and a low negative appendicectomy rate for patients with suspected appendicitis. Scott el al. (100) included 464 patients with suspected appendicitis. They applied the Appendicitis Inflammatory Response (AIR) score for all patients (low risk: AIR score <5, intermediate 5-9, high risk for appendicitis score >9), use of additional imaging (US and CT scan) was at the discretion of the surgical team. Negative and positive likelihood ratios (LR) were calculated afterwards, for ruling out appendicitis with help of additional imaging and related to the risk of having appendicitis based on the AIR score. On the basis of their results they developed a pathway with specific imaging modalities for patients with low, intermediate or high risks for having appendicitis, they did not prospectively evaluate this pathway.

Table 6.3 Patient characteristics, additional imaging and final outcomes of the five prospective studies.

	Patients	Age	Gender	Diagnostic proposal	Diagnostic accuracy	Complications	Mortality	LOS
	N	(years)	Female (%)			N (%)	N (%)	(days)
Ng et al.								
Intervention	57	-	-	24 hours observation and routine CT scan	78%	-	0 (0%)	5.3 (1-31)
Control	63	-	-	24 hours observation and selective CT scan	75%	-	7 (11.1%)	6.4 (1-60)
Lameris et al.	1021	47 (19-94)	565 (55.3%)	Routine US, selective CT scan	84.8%	-	14 (1.4%)	-
Toorenvliet et al.	802	-	-	Routine US, selective CT scan	96.7%	-	-	-
Scott et al.	464	27 [16]	292 (62.9%)	AIR score + US or CT scan	-	-	-	1.8 (1.0–3.0)
Majewski et al.	120	39 (13-79)	64 (53.3%)	Routine US, diagnostic laparoscopy	88.6%	-	9 (7.5%)	5 (0-77)

US; ultrasound scan, CT; computed tomography, LOS; length of stay, -; information not given in full text article
LOS for Ng et al. is mean (range), for Scott et al. median (IQR), for Majewski et al. median (range)
Toorenvliet et al. and Scott et al. only included patients with suspected appendicitis.

The remaining two prospective cohort studies were for all cause acute abdominal pain(39, 57). Lameris et al. (39) included 1021 patients with abdominal pain in a multicentre prospective cohort study. The methodology employed in this study was to give all patients routine assessment, plain radiography, US and CT scan, and then to post-hoc apply eleven diagnostic pathways based on combinations of imaging. They concluded that the pathway associated with the highest diagnostic accuracy was routine US and CT scan if the US results were negative (sensitivity of 94% and specificity of 68%). Use of this pathway lead to a total of 1021 US (100%) and 501 CT scans (49.1%). They did not prospectively evaluate this pathway and they did not address the complication rate or length of stay for the included patients.

In the remaining clinical cohort, Majewski et al. (57) compared the results of single operator diagnostic laparoscopies (DL) in 120 patients with acute abdominal pain (both traumatic and non-traumatic) compared to diagnostic accuracy and length of stay to 310 patients that were diagnosed without DL and treated by a different consultant. This study concludes that diagnostic laparoscopy was associated with a diagnostic accuracy of 88.6%. Length of stay was a median of 5 days in the DL group compared to 6 days in the control group (p<0.0003). Therefore, the authors conclude that DL is accurate for diagnosing patients with both traumatic and non-traumatic abdominal pain and reduces length of stay. On the basis of their results they designed a pathway that includes standard US as part of the work up of the patients and to proceed with a DL when diagnosis is still uncertain. They did not prospectively evaluate their pathway.

Across these five clinical studies, data on diagnostic accuracy was given in four cases for the whole cohort, and ranged from 75% to 96.7%, although the latter was in suspected appendicitis only (table 6.3). The fifth clinical study reported diagnostic accuracies, per risk stratification on the basis of the AIR score(100). Routine US followed by selective use of CT appeared to be associated with the highest diagnostic accuracy across these studies. None of the studies provided any data on complications. While mortality data and length of stay data was provided in three studies, comparison across these studies for these parameters is not warranted due to differences in patient cohorts.

The other five included non-prospective studies developed a pathway based on a literature review alone. Three were developed to aid the differentiation of acute from non-acute abdominal pain (37, 149, 150), one was developed to improve the diagnosis of appendicitis(105) and the last to improve diagnosis of abdominal pain in the elderly(24). Three of these five concluded routine US was essential as part of the diagnostic work-up(37, 105, 150), one study opted for use of routine CT scanning to aid diagnosis(149) and the last study concluded imaging (CT or US scan) may either be required based on the differential diagnosis(24).

Quality assessment

The level of evidence amongst the ten included studies ranged between 1b and 5, according to the Oxford scale of level of evidence. The MINORS score could only be calculated for the studies that included patients and were non-randomised and ranged from 11-16 (table 6.1).

The complexity assessments are summarised in table 6.2, there was no relevant discrepancy between the four researchers and their ranking of the pathway as easy, medium or hard to follow. Pathways that were deemed easy to follow by the researchers had a lower number of end and decision points compared to the medium or difficult to read pathways (average number of endpoints respectively 2, 6 and 8 and decision points 4, 6 and 14, respectively). No complexity assessment for Lameris et al.(39) study could be made as this study describes multiple pathways.

6.4 Discussion

This systematic review included ten studies describing a pathway for diagnosing patients presenting with abdominal pain or a specific diagnosis causing abdominal pain to the ED. Five studies were literature reviews describing a pathway on the basis of their search and with or without the advice of an expert steering group(24, 37, 105, 149, 150). Five studies based their pathway on the results of their prospective cohorts, two of these studies were for patients with suspected appendicitis(39, 44, 57, 100, 116). Effects of the introduction of the pathways on costs, complications and length of stay were scarcely reported.

Using pathways to diagnose patients presenting with abdominal pain to the ED can be extremely valuable to reduce inter-collegial differences, improve communication, standardise use of diagnostic tools and improve thereby improve patient care. Multiple specialties (including: emergency physicians, gynaecologists, urologists, general surgeons, etc.) can be involved in this diagnostic process and therefore a pathway should be widely applicable to all(142, 143).

Differentiating between urgent and non-urgent patients prior to the use of diagnostic tests may help prioritise the use of advanced imaging and access to theatre. The definition of an urgent patient in two of the included studies is someone requiring treatment for the presumed underlying condition within 24 hours(37, 39). This group needs prompt access to imaging, endoscopic management and theatres in order to minimise the morbidity and mortality associated with the underlying disease while also reducing length of stay. While non-urgent patients may need admission, access to additional diagnostic tests or even require surgery, they do not require this with the same priority as urgent patients. Furthermore, some non-urgent patients may be better managed as outpatients if they can be safely discharged in order to reduce pressure on strained hospital resources. To our knowledge, there is to date no evidence about whether this distinction between urgent and non-urgent patients presenting with abdominal pain can be safely made prior to the use of advanced imaging.

Three pathways included in this study were for patients with suspected appendicitis(100, 105, 116). Appendicitis is the most common diagnosis for patients referred to general surgery with acute abdominal pain(9). The diagnosis, however, can be obscure and therefore diagnostic accuracy on the basis of clinical history and examination and laboratory results alone, can be difficult. Some centres support the use of routine imaging in the form of US and/or CT scanning. It has been shown that routine diagnostic imaging lowers the negative appendicectomy rate (NAR) to 1.7-6.2%(107, 109, 110). While in hospitals where imaging is used selectively, the NAR can be between 20.6 and 38.9% (111, 112) (see also chapter 3). Two of the three pathways for diagnosing patients with suspected appendicitis included in this study support the use of routine US(105, 116), all three studies advocated the use of selective CT scanning.

Of the other seven studies describing a pathway for diagnosing patients with abdominal pain, only three were based on results from a prospective study. One of them supports the use of routine CT scanning(44), one the use of routine US followed by a CT scan if US results are negative(39) and the last one the use of DL when diagnosis after routine US remains unclear. Diagnostic accuracy is high in all of the three studies due to the routine use of imaging. However, applying any of these three pathways will lead to a substantial increase in the number of requests for imaging while none of these studies have reported results of costs analysis, a reduction in the incidence of morbidity, mortality or length of stay. The remaining four studies base their pathways on their literature review (24, 149, 150). The use of imaging differs per study, two support the use of routine US followed by selective CT scanning(37, 150), one uses both forms of imaging selectively(24) and the last one supports the use of selective US but routine use of CT scans(149).

In this study the pathways for diagnosing patients with abdominal pain, published in peer reviewed journals were evaluated. However, there are a number of pathways published on the internet including UpToDate(151) which describes a pathway for diagnosing patients over fifty years of age and women of childbearing age with abdominal pain. The document has an educational approach. The American Family Physician (AFP) (152) describes multiple

pathways depending on the location of the pain and the characteristics of the patients, but mainly targets the general practice setting. Lastly the Royal College of Surgeons(89) describes a pathway in which they differentiate between non-urgent, intermediate and urgent patients. They suggest immediate senior (registrar or consultant) review for the urgent patient and observation with or without additional imaging for the intermediate patient. However, none of these pathways have been prospectively evaluated and therefore no conclusions about efficiency and reduction in morbidity, mortality or length of stay can be drawn.

Evaluating the use of imaging of the 10 included studies, most studies recommend the use of routine US followed by CT scanning when there is still diagnostic uncertainty. However, accuracy for US varies widely in literature, with sensitivities as high as 77-91% in countries in Western Europe (40, 116), where US appears to be the standard diagnostic tool. On the other hand, US accuracy is operator and hospital dependent and significant lower sensitivities have been reported as well(117, 118). Another issue with US is the access of it out of hours is hospital dependent. In hospitals in New Zealand US are most commonly performed by radiographers within office hours and radiology registrars out of hours, as the last group is often occupied by other acute radiology requests, access to US can be delayed. Use of CT scans comes with high diagnostic accuracy [25, 34], but there are also significant downsides to routine use of this diagnostic tool, including: costs, longer waiting times, patient radiation exposure, contrast induced nephropathy and contrast allergies, for the use of CT scans [35-37]. Furthermore, standardised imaging (US or CT) will lead to over imaging a significant proportion of patients presenting with self-limiting or non-urgent abdominal pain.

Part of the assessment of the described pathways was to look at the complexity of the pathways. There is no standardised assessment tool to evaluate the complexity and the quality of a pathway, therefore the ranking method described was developed for this study. Two studies had an easy, five a medium and two a difficult to follow pathway. There was a good correlation between the complexity score given by the researchers and the number of decision and end points in each pathway. Aiming for a pathway that is easy to

medium to follow would be preferable, as implementing a difficult pathway will likely result in reduced cooperation from the involved clinicians.

Limitations

Limitations of this study should be considered. Firstly, the design of the study means that only published literature could be included. Secondly, difficulties arose when comparing the different pathways described, as a number were designed for sub-diagnosis like appendicitis, while another focused mainly on abdominal pain in the elderly. However, the aims were to describe the pathways published in peer reviewed journals and their use of additional imaging and whether this has had an effect on final outcomes.

6.5 Conclusion

Multiple pathways have been described for diagnosing abdominal pain. This study shows that only a small proportion have been published in peer reviewed literature and the majority of these pathways have not been prospectively evaluated. Most of the included studies support routine imaging either in the form of CT scans or routine US followed by CT scan when there is ongoing diagnostic uncertainty. This will improve early and accurate diagnosis for the patient presenting with abdominal pain, but has not been proven to reduce complication rate, mortality or length of stay. Also none of the studies included evaluated use of hospital resources, waiting times and cost implications.

On the basis of this systematic review it can be concluded that none of the pathways described can be readily implemented to aid the assessment process for patients presenting with abdominal pain. It would clinically be useful to prioritise patients, to assure fast access to additional diagnostic tests and theatre for patients who are deemed urgent on assessment and to aim for non-urgent or outpatient management for patients who do not need to have this as urgently. Thereby, using hospital resources optimally. However to date we don't know whether we can accurately make this assessment prior to the use of additional diagnostic tests (US or CT scan).

Section 3

Stepwise introduction of a new pathway to benefit the assessment of patients presenting with acute abdominal pain

Chapter 7: Can surgical registrars accurately identify the urgent from the non-urgent patient presenting with acute abdominal pain?

7.1 Introduction

To improve the diagnostic process for patients presenting with acute abdominal pain, it would be useful to differentiate patients with urgent diagnoses from patients with less urgent diagnoses prior to the use of imaging. This would aid prioritisation of additional diagnostic tests and access to theatre. The definition of an urgent patient in previous studies is someone requiring treatment for the presumed underlying condition within 24 hours(37, 39). This group needs prompt access to imaging, endoscopic management and theatres in order to minimise the morbidity and mortality associated with the underlying disease. While non-urgent patients may need admission, access to additional diagnostic tests or even require surgery, they do not require this with the same priority as urgent patients. To our knowledge, there is to date no evidence about whether this distinction between urgent and non-urgent patients presenting with abdominal pain can be safely made prior to the use of advanced imaging.

Determining whether surgical registrars can safely differentiate urgent from non-urgent patients presenting with acute abdominal pain is an essential first stepping stone before future quality improvement initiatives for the assessment process can be implemented. The aim of this study was therefore to evaluate whether we can accurately differentiate the urgent from the non-urgent patients presenting with abdominal pain prior to the use of advanced imaging.

7.2 Methods

A prospective clinical study was performed at Wellington Regional Hospital.

The general surgery department

The general surgery department employs twelve consultant general surgeons and sixteen registrars of which six are senior registrars (defined as having at least 5 years of post-graduate experience). In New Zealand registrars become senior when selected into surgical training, this is often after their fourth or fifth year post graduation from medical school.

All patients are seen by the ED triage nurses. They assign a code to a patient based on the urgency to which they think the patient needs to be treated. Patients were, depending on this code and the EWS, either reviewed by a general surgery registrar in the ED or in the ASU(83).

Inclusion criteria

All patients over 16 years of age with abdominal pain who were assessed or admitted by the department of general surgery between 16th of November 2016 and continued to the day the three-hundredth patient was enrolled, which was achieved on 23rd April 2017. Patients were excluded on the basis of more than 7 days duration of pain, recurrent presentations for the same pain and complications from a recent admission or operation within the last three months.

Definitions

Urgent patients were defined as requiring treatment in the form of an operation, radiologic drainage, endoscopic management or high dependency unit (HDU) or ICU support within 24 hours of admission. Non-urgent patients were defined as not requiring any of these treatment options within 24 hours of

admission. Assessing doctors were asked to make this differentiation on the basis of their initial assessment, including: patient history, examination, urine analysis, blood results and where indicated plain X-rays, but explicitly prior to the use of advanced imaging or operation. They were asked to complete a form on which they indicated, for each patient they assessed, whether this was an urgent or a non-urgent patient and on what criteria they based this decision (overall appearance of the patient, observations (heart rate, blood pressure or temperature), abdominal examination, blood or plain X ray results). Registrars were also asked to state how many years of post-graduate experience they had. Forms were otherwise anonymous (figure 7.1).

Urgent vs Non-Urgent abdominal pain

Patient label

Does this patient require treatment <24hrs? (surgical/radiological (drainage)/endoscopic/ICU support)

Yes ☐   No ☐

Are you concerned about:

- Overall appearance   Yes ☐   No ☐
- Heart rate   Yes ☐   No ☐
- Bloodpressure   Yes ☐   No ☐
- Temperature   Yes ☐   No ☐
- Abdominal examination   Yes ☐   No ☐
- WCC   Yes ☐   No ☐
- CRP   Yes ☐   No ☐
- Other bloods   Yes ☐   No ☐
- X rays (not done = no)   Yes ☐   No ☐

Additional information:

Assessment completed by PGY: 0 1 2 3 4 5 6 7 8 9 >10

Figure 7.1 Urgent vs non-urgent form

Data collection

Forms were collected from the ASU, data were also obtained from the admission and inpatient notes, radiology reports, theatre documentation and laboratory results. Patients were followed up for three months after the day of discharge in order to obtain data about re-admission and ninety day complication rates.

All cases were reviewed after three months of follow up and based on the review and the final diagnosis it was decided whether the presentation was urgent or non-urgent, using the previously defined criteria. The three reviewing authors were blinded to the outcome of the initial assessment.

The initial assessment of urgency was compared against the final determination of whether the presentation was urgent or non-urgent. In this manner the true positive group (where patients were deemed urgent on initial assessment and on final diagnosis), false positive group (urgent on initial assessment but not on final diagnosis), true negative group (non-urgent on initial assessment and on final diagnosis) and false negative group (non-urgent on initial assessment and urgent on final diagnosis) were defined. The sensitivity and specificity of the initial assessment could therefore be calculated.

Ethical approval

See chapter 2.2.

Statistical analysis

A power analysis was performed and it was estimated that the smallest group should contain a minimum of 50 patients to enable statistical analysis. Based on the clinical assumption that around 20-25% of the patients presenting with abdominal pain would be diagnosed with an urgent diagnosis. A minimum cohort of 300 patients was deemed sufficient.

The patients that were considered to have an urgent presentation based on their final diagnosis were compared to non-urgent patients for patient

characteristics, work up, theatre data and final outcomes (length of stay, re-admissions and complications).

The data were analysed using the same statistical principles as explained in the methods section of chapter 2.

7.3 Results

Between the 16th of November 2016 and 23rd of April 2017 a total of 301 patients who fulfilled the inclusion criteria were included. The median age was 46 years old (29-65 years) and 50.5% were female. The majority (58.1%) of the patients were referred by ED, 46.5% of the patients had co-morbidities at the time of presentation and 35.2% had a history of previous abdominal surgery. On the basis of the initial assessment 93 (30.9%) patients were deemed to be urgent, compared with 83 (27.6%) patients who were considered urgent on the basis of their final diagnosis. The comparisons in this section between urgent and non-urgent patients is based on the latter. Demographic characteristics (such as age, ethnicity, gender, etc.) did not differ significantly between urgent and non-urgent patients (table 7.1).

Table 7.1 Comparison of patient characteristics between urgent and non-urgent patients

	Non-urgent patients (N=218)	Urgent patients (N=83)	p value
Age	48.5 [19.8]	46.3 [21.6]	0.407
Gender			
Female	111 (50.9%)	41 (49.4%)	0.457
Ethnicity			
NZ/European	177 (81.2%)	70 (84.3%)	0.666
Maori	13 (6.0%)	4 (4.8%)	
Pacific	10 (4.6%)	5 (6.0%)	
Asian	14 (6.4%)	2 (2.4%)	
Other	4 (1.8%)	2 (2.4%)	
Relevant medical history	107 (49.1%)	33 (39.8%)	0.147
Previous abdominal surgery	79 (36.2%)	27 (32.5%)	0.547
Referrer			
ED	128 (59.0%)	47 (57.3%)	0.806

Mean [SD] for parametric data and N (%) for discrete. NZ; New Zealand, ED; emergency department

Patient work-up including observations at the time of assessment, findings on clinical examination, laboratory results and the use of imaging are summarised in table 7.2.

Table 7.2 Examination findings, blood results and use of imaging for the two groups

	Non-urgent patients (N=218)	Urgent patients (N=83)	p value
Vitals			
Temperature	36.4 [19.8]	36.5 [21.6]	0.790
Heart rate	75 (67-86)	82 (73-94)	0.001*
Mean arterial pressure	92 (85-101)	92 (81-101)	0.397
Examination			
Looks unwell	38 (17.4%)	33 (39.8%)	<0.001*
Concerns abdominal examination	60 (27.5%)	58 (69.9%)	<0.001*
Presence of peritonism	32 (14.7%)	47 (56.6%)	<0.001*
Days of pain	2 (1-3)	1 (1-3)	0.210
Bloods			
Haemoglobin	141.8 [16.9]	141.3 [17.3]	0.803
WCC	10.2 (8.1-12.8)	12.3 (9.5-16.3)	<0.001*
CRP	7 (3-26)	20 (5-80)	<0.001*
Imaging			
US	46 (21.1%)	10 (12.0%)	0.119
CT scan	76 (34.9%)	38 (45.8%)	0.282

Mean [SD] for parametric, median (IQR) for non-parametric and N (%) for discrete data. Heart rate in beats per minute. haemoglobin (g/ml), WCC; white cell count (10^9/L); CRP; C-reactive protein (mg/L); US; ultrasound scan; CT; computed tomography. * Significant findings (p ≤0.05)

Findings on clinical examination differed significantly between urgent and non-urgent patients. Urgent patients were more likely to look unwell from the end of the bed (39.8% vs 17.4%, p<0.001), assessing doctors were more frequently concerned about the findings of their abdominal examination (69.9% vs 27.5%, p<0.001) and these patients were more likely to have peritonism on abdominal examination (56.6% vs 14.7%, p<0.001). The median heart rate was higher for urgent patients compared to non-urgent patients (82 vs 75 beats per minute, p=0.001). The number of days of pain prior to their presentation was not significantly different between groups (p = 0.210). Median WCC and CRP were higher for urgent patients (12.3 vs 10.2 (10^9/L) and 20 vs 7 (mg/L) respectively, p<0.001 for both). The majority of patients (54.5%) underwent a form of advanced imaging to aid with diagnosis, the use of imaging was not significantly different between urgent and non-urgent patients.

The majority (70.8%) of the patients were assessed by junior registrars. Overall sensitivity of recognising the urgent from the non-urgent patients was 74.7% and specificity was 89.9%. Accuracy was significantly higher amongst senior registrars (sensitivity 82.6% and specificity 96.9%, p=0.002), (table 7.3).

Table 7.3 Comparison of accuracy of identifying the urgent patients between junior and senior registrars

	Junior (N=213)	Senior (N=88)	Total (N=301)
True positives	43 (20.2%)	19 (21.6%)	62 (20.6%)
True negatives	124 (58.2%)	63 (71.6%)	187 (62.1%)
False positives	29 (13.6%)	2 (2.3%)	31 (10.3%)
False negatives	17 (8.0%)	4 (4.6%)	21 (7.0%)
Sensitivity	71.7%	82.6%	74.7%
Specificity	81.0%	96.9%	89.9%

Junior registrars have < 5 years of post-graduate experience, senior registrar's ≥ 5 years of post-graduate experience.

Twenty-three (27.7%) of the 83 urgent patients, were seen by senior registrars. Comparing the assessment of urgent patients between junior and senior registrars, the senior registrar more often found that the patient looked unwell from the end of the bed (60.9% vs 31.7%, p=0.015). The senior registrar was concerned about the findings on abdominal examination in 82.6% patients, compared to 65.0% patients for when a junior registrars assessed the urgent patient (p=0.118). Senior registrars were more likely to identify peritonism when examining an urgent patient, compared with a junior registrar (73.9% vs 50.0%, p=0.049).

Twenty-one patients were not recognised as being urgent on their initial assessment but were defined as urgent on final assessment, four of them were assessed by senior registrars. Of the latter four patients, three had appendicitis and one patient had diverticulitis with a localised perforation. Seventeen out of 21 missed urgent patients were seen by junior registrars, six had appendicitis, six had small bowel ischaemia, three had cholangitis, one had gangrenous cholecystitis and one had a splenic abscess with sepsis. Thirty-one patients were thought to have an urgent diagnosis on their initial assessment, but did not have an urgent diagnosis based on their final diagnosis. The majority (63.6%) were thought to have appendicitis.

In total 82 (27.2%) patients required an operation during their admission. Urgent patients were significantly more likely to require an operation (p<0.001) and had a significantly reduced time from presentation to theatre (p=0.002) (table 7.4).

Twenty-one (25.3%) urgent patients were managed non-operatively, of them three (3.6%) had radiologic drainage, seven (8.4%) had endoscopic management and eleven (13.3%) had medical treatment requiring ICU or HDU support. Overall length of stay was statistically significantly longer for urgent patients (median of 4.1 days vs 1.3 days, p<0.001). Urgent patients suffered more complications, both in-hospital and within 90 days (p<0.001 and p=0.001, respectively).

Table 7.4 Final outcomes for urgent and non-urgent patients

	Non-urgent patients (N=218)	Urgent patients (N=83)	p value
Theatre	20 (9.2%)	62 (74.7%)	<0.001*
Time to theatre	23.7 (18.4-74.2)	14.4 (9.2-22.7)	0.002*
In hospital complications	9 (4.1%)	20 (24.1%)	<0.001*
LOS	1.3 (0.6-3.0)	4.1 (1.9-7.0)	<0.001*
Re-presentations (90 day)	29 (13.3%)	14 (16.9%)	0.495
Complications (90 day)	35 (16.1%)	29 (33.9%)	0.001*

Median (IQR) for non-parametric and N (%) for discrete data. Time to theatres in hours and length of stay in days. LOS; length of stay
* Significant findings (p ≤0.05)

Of the 29 patients that had an in-hospital complication, two died during their admission. Both patients had an urgent diagnosis that would typically require an operation, but were deemed to be not fit for this or they decided against treatment and were treated with palliative intent from the outset. Five patients had a serious complication requiring intervention or ICU support (Clavien Dindo grade 3 and 4)(153). Two patients had a non-urgent final diagnosis and three had an urgent diagnosis.

Lastly 22 patients had a minor complication (Clavien Dindo grade 1 or 2), of these, fifteen (68.2%) patients had an urgent diagnosis (table 7.5). The number of re-presentations within 90 days from discharge did not differ significantly between urgent and non-urgent patients (p=0.495).

Table 7.5. In-hospital complication summary

Clavien-Dindo:	n	Explanation
1	6	Ileus, delirium
2	16	Wound infection, AF, pneumonia, TPN, thrombophlebitis
3	3	PE, stoma ischaemia, bile leak
4	2	MI, aspiration pneumonia (requiring ICU admission)
5	2	Palliative
Total	29	

AF; atrial fibriliation, TPN; total parenteral nutrition, PE; pulmonary embolism, MI; myocardial infarction, ICU; intensive care unit

7.4 Discussion

Differentiation between urgent and non-urgent patients prior to the use of advanced imaging can be accomplished by registrars with reasonable sensitivity and specificity, with senior registrars making this distinction with greater accuracy than their junior counterparts. Overall, close to a third of the patients presenting to the general surgery department with acute abdominal pain were deemed urgent.

The definition of urgent was patients who required an operation, radiologic drainage, endoscopic management or ICU support within 24 hours of presentation. This is a more clinically useful definition than an alternative where urgent patients have been defined as requiring any form of medical treatment within 24 hours (e.g. oral antibiotics)(37, 39). Using the latter definition leds to categorising patients such as those with simple diverticulitis as urgent, while they can be treated with oral antibiotics and safely discharged from hospital.

Urgent patients had a statistically significant higher heart rate, WCC and CRP compared to non-urgent patients, but the median heart rate for an urgent patient in this study was still within the normal range and the median WCC and CRP at time of admission for the urgent patients were only marginally elevated. These results are comparable to previous studies who agree with the finding that WCC and CRP are poor discriminators for differentiating urgent from non-urgent patients presenting with acute abdominal pain(36, 101).

What clearly does differentiate an urgent patient from a non-urgent patient are the findings during examination of the patient. These results show that when a senior registrar assessed an urgent patient they were more likely to recognise them as looking unwell from the end of the bed and they found peritonism on abdominal examination more often compared to junior registrars. This implies that senior registrars have a more developed 'instinct' for defining a patient as well or unwell and this is likely a consequence of their level of clinical experience. These results are comparable to a recent study done in an ED, where they concluded that there was more inter-observer disagreement between junior residents and senior residents or emergency physicians, while senior residents and consultants had a higher level of agreement(32).

Another study evaluated the diagnostic accuracy of initial clinical assessment between registrars and consultants and concluded that there was no difference in accuracy between the two(31). This study evaluated how often assessing doctors made the correct specific diagnosis prior to the use of advanced imaging. Although this is an interesting outcome, we believe it is often not necessary to have a correct initial diagnosis but it is more important to differentiate the unwell from the well patients and prioritise unwell patients to the next appropriate step for obtaining a final diagnosis and prompt treatment.

This study was a non-interventional study, there were no consequences attached to categorising a patient as urgent or non-urgent. However, this study showed that those patients categorised as urgent more commonly needed an operation, had a longer length of stay in hospital and had increased risk of in-hospital and ninety day morbidity. These patients benefit from early treatment and if they are accurately prioritised and treated as such it may reduce their morbidity and ultimately length of stay.

Limitations

A limitation to the current study design is that forms may have been missed due to heavy workload. Furthermore, to avoid bias, registrars were asked not to fill in forms retrospectively, although it was impossible to check that this wasn't occurring. Data about the assessments and findings on examination was prospectively collected from the forms. Presence of peritonism, whether the patient looked unwell and whether the registrar was concerned about the findings on examination are therefore dependent on the registrar and the experience. Finally, the decision to call registrars senior when they had more than five years of post-graduate experience is partially arbitrary and partially based on when registrars usually enter the general surgery training program and the increased responsibilities associated with that.

7.5 Conclusion

From this study we can conclude that registrars can accurately identify the urgent from the non-urgent patient presenting with acute abdominal pain, although senior registrars are more accurate compared to junior registrars. The 'end-of-the-bed-o-gram' and findings on clinical examination were better predictors for differentiating the unwell from the well patient compared with laboratory results. It is clear that there seems to be a learning curve for registrars in recognising the urgent from the non-urgent patients. Junior registrars should be exposed to acute surgical patients with appropriate senior supervision as early differentiation between urgent and non-urgent patients may be helpful in order to prioritise access to diagnostic tests and theatre.

The results of this study implies that a prioritisation prior to the use of additional diagnostic tests is useful and safe. With a future project (chapter 8) it is intended to prioritise patients on initial assessment.

Chapter 8: Reducing length of stay for patients presenting acutely with non-surgical abdominal pain.

8.1 Introduction

In chapter 2 we found that the number of patients admitted to general surgery with abdominal pain between 2004 and 2014 has increased by 74.0% (1108 admissions in 2004 to 1928 admissions in 2014), while the population over the same time period increased by only 9.6%(103). An increasing proportion of these patients turn out to have a non-surgical diagnosis (e.g. gastro-enteritis, constipation, non-specific abdominal pain or pain caused by a diagnosis usually treated by another specialty)(3, 103). In the prospective cohort of patients studied in the previous chapter, approximately 40% were admitted with non-surgical abdominal pain, this accounts for around 650 admissions per year(103, 154). Early differentiation between a patient presenting with a non-surgical problem and a patient with acute pathology who needs urgent surgical intervention is essential to optimise patient flow in the ED, but also on the wards(46, 103, 133, 154).

The previous chapter shows that registrars can accurately make the differentiation between urgent and non-urgent patients presenting with abdominal pain on assessment(154).

The use of CT scans to aid early diagnosis for patients presenting with acute abdominal pain has increased over the last decade(41, 43, 103). With this increase, however, a simultaneous increase in the proportion of scans that are negative for acute pathology is observed (chapter 2). Also, this diagnostic tool comes with significant downsides, including: radiation exposure, increased waiting times, costs and carries risk of contrast induced allergy(45, 46, 119, 128, 133). Furthermore, the study explained in chapter 4, found that about one-fifth of the scans requested for a patient presenting with acute non-traumatic abdominal pain was not indicated according to both radiology and general surgery consultants and when CT scans were indicated the majority required it non-urgently (>24 hours)(155).

The latter findings suggests that more scans are performed for patients with a non-surgical diagnosis. Optimising the use of additional imaging would result in more efficient use of hospital resources.

To address both of these growing problems a quality improvement programme was implemented aimed at optimising the early differentiation of patients presenting with abdominal pain to encourage early discharge and wise use of scarce hospital resources for patients with a suspected non-surgical diagnosis.

The aim of this study was to evaluate whether the implementations made to the surgical department resulted in a reduction in length of hospital stay and a reduction in the use of additional imaging (US or CT) for patients presenting with non-surgical diagnoses, without increasing the number of re-admissions or re-presentations to ED. Furthermore, the secondary aim was to evaluate whether the above effect would result in improved access to hospital resources for patients presenting with surgical diagnoses and thereby reduce morbidity and mortality for this group.

8.2 Methods

A prospective clinical study was performed at Wellington Regional Hospital.

Definitions

In the previous chapter a differentiation was made between urgent and non-urgent patients. In this chapter the differentiation is between surgical and non-surgical patients. Patients with a non-surgical diagnosis should not require admission, unless for social reasons. While patients with a non-urgent but surgical diagnosis (e.g. uncomplicated diverticulitis or a partial small bowel obstruction), often require admission for a couple of days.

Summarising the assessment process before implementation of quality improvement programme

The ASU had ten admission beds in three rooms and four assessment beds in individual rooms. During their assessment patients were ideally seen in a single room. Patients would be seen by the nursing staff and one of the registrars. They would stay in the assessment room until blood results and when indicated additional imaging results were available and a decision could be made about whether the patient required admission or discharge. When the ASU assessment beds were occupied, additional patients had to be seen in the ED.

Registrars would request a CT scan when they considered them indicated and discuss the clinical information with the on call radiologist and prioritise the scan accordingly. A senior review or opinion was not always obtained prior to requesting the scan.

Part of the ASU introduction was a twice daily consultant led ward round. In reality however, the consultant would round in the morning on all the acutely admitted patients and would round at of the end of the day before afternoon handover on selected patients.

Assessment process after implementation of quality improvement programme

The first implementation was the design of a waiting area, in this area four comfortable recliner chairs were placed separated by curtains. Because of the introduction of the waiting area the ASU went from ten to eight inpatient beds. Patients would wait in one of these chairs prior to their assessment and again after their assessment while waiting for the results of further investigations.

Figure 8.1 Assessment bay with comfortable recliner chairs. This is a simulated set up with hospital staff.

The four single assessment rooms remained unchanged and were still available for the actual patient assessment and for any patients who were not well enough to wait in a chair after being examined.

An online assessment form was created to aid documentation. Part of this form was a mandatory impression statement of whether the patient had an urgent or non-urgent presentation (see appendix 1). Urgent patients were defined as requiring treatment in the form of an operation, radiologic drainage, endoscopic management or HDU or ICU support within 24 hours of admission. This differentiation was made after the patient's initial assessment (history,

examination, bloods and/or X-rays), but prior to the use of additional imaging or operation.

All CT scans requested for patients with abdominal pain had to be discussed with the consultant. In addition to the daily CT scan slot available for ASU patients a new CT scan slot was created, available twice a week and called the urgent outpatient slot. These were reserved for patients presenting with abdominal problems that required a CT scan, but did not need to stay in hospital waiting for the scan nor could they wait two or more weeks for a normal outpatient slot (e.g. patient with presumed diverticulitis, but well enough to be discharged on oral antibiotics).

The last implementation was education of the different members of the surgical team involved in the acute care of patients. Nurses were encouraged to help with patient flow by informing registrars about results of investigations and escorting patients from the assessment room to the waiting area and vice versa. On arrival patients received an information leaflet about the assessment process and posters were on the wall in the assessment and waiting area's to emphasize that the ASU was an assessment and not an admission unit (see appendix 2 and 3). Consultants were encouraged to do a twice daily ward round where they were also asked to review not only the unwell patients but also the patients with suspected non-surgical diagnoses and to make decisions about early discharge.

Monthly departmental meetings were scheduled. Before the study began, these focussed on the high admission rates for patients with non-surgical problems and the consequences of this. During the study, updates were given about admission and early discharge rates for patients presenting with non-surgical problems. The use of CT scans was also discussed. Every month the results were shown in comparison to previous month's results. Lastly, teaching sessions for the registrars about assessing and managing patients presenting with acute abdominal pain, were given.

Inclusion criteria

All patients over 16 years of age with abdominal pain who were assessed or admitted by the department of general surgery between 18th of September 2017 and 18th of January 2018, were included. Patients were excluded according to the same criteria as in chapter 2 and 7.

Data collection

Data were obtained from the admission and inpatient notes, radiology reports, theatre documentation and laboratory results. Information was obtained from these records about patient characteristics, existing relevant (to their presentation with abdominal pain) co-morbidities at the time of assessment and information about previous abdominal surgery. Time of surgical assessment was chosen as the moment the registrar started the documentation in the electronic patient's notes system, as this was the most objective time that could be logistically obtained and was not influenced by ED waiting times. Also dates and time of discharge were obtained to calculate the length of hospital stay. Information was obtained about complications (categorised according to the Clavien-Dindo classification(153)), re-presentations to ED or admissions and about changes in the discharge diagnosis due to results of outpatient tests or re-presentations. All patients were followed up for a minimum of ninety days post discharge.

The initial assessment of whether the patient presentation was deemed urgent or non-urgent was dependent on the registrar assessing the patient. This assessment was included in the online assessment form. The final differentiation between urgent and non-urgent was based on the final diagnosis and this was done according to the same principles explained in chapter 7. This final differentiation between urgent and non-urgent was used for comparisons between the two groups with regards to use of imaging, LOS, patient characteristics, etc.

The patient's characteristics, work up, theatre data and final outcomes (length of stay, re-admissions and complications) were compared between the

first two months (group 1) and the last two months (group 2) of the study period. It was decided to compare these two groups as it was felt that the implementations may take some time to show their effect. This was based on the results from previous studies evaluating the stages implementing a new protocol(16-18).

Ethical approval

See chapter 2.2.

Statistical analysis

Univariate analysis was first performed using a binary logistic regression to determine which variables were significantly associated with early discharge for patients presenting with non-surgical diagnoses. To identify independent predictors, variables with a p value of <0.2 in univariate analysis were subsequently included in a stepwise logistic regression analysis. The data were analysed using the same statistical principles as explained in the methods section of chapter 2. Additionally, for normally distributed data comparison between groups was calculated using the independent sample t-test.

8.3 Results

During the study period a total of 889 patients were acutely assessed by general surgery, 454 patients fulfilled the inclusion criteria. The majority of the patients not included in the study presented with a complaint other than abdominal pain (e.g. skin abscess or hernia). Patients were divided into two groups based on the date of presentation, group 1 consisted of the patients who presented between 18th of September and 17th of November 2017 and included 213 patients (46.9%) and group 2 included 241 (53.1%) patients who presented between 18th of November 2017 and the 18th of January 2018. Patient characteristics did not differ between the two groups, nor did their in-patient management (table 8.1).

Table 8.1 Patient characteristics and in-hospital management for the two
groups

	Group 1 N=213	Group 2 N=241	p value
Age (years)	47 (30-63)	48 (30-66)	0.667
Gender (%)			
Female	126 (59.2%)	137 (56.8%)	0.619
Ethnicity (%)			0.825
NZ/European	150 (70.4%)	170 (70.5%)	
Maori	24 (11.3%)	28 (11.6%)	
Pacific	15 (7.0%)	16 (6.6%)	
Asian	16 (7.5%)	22 (9.1%)	
Other	8 (3.8%)	5 (2.1%)	
Co-morbidities	108 (50.7%)	132 (54.8%)	0.386
Previous abdominal surgery	95 (44.6%)	121 (50.2%)	0.233
Referrer (ED)	113 (53.1%)	142 (58.9%)	0.275
Hb	138 (130-150)	139 (129-151)	0.537
WCC	11.3 [4.6]	11.1 [4.1]	0.656
CRP	39.2 [65.9]	41.7 [76.0]	0.705
Imaging			0.405
None	72 (33.8%)	100 (41.5%)	
US	52 (24.4%)	51 (21.2%)	
CT	74 (34.7%)	76 (31.5%)	
Both	15 (7.0%)	14 (5.8%)	
Operation (yes)	69 (32.4%)	71 (29.5%)	0.499

NZ; New Zealand, ED; emergency department, Hb; Haemoglobin (g/L), WCC;
White Cell Count (10^9/L), CRP; C-Reactive Protein (mg/L).US; ultrasounds scan,
CT scan; Computed Tomography scan.

Patients with a non-surgical diagnosis

A total of 204 (44.9%) patients had a non-surgical diagnosis. In 130 (63.7%) patients this was non-specific abdominal pain, in 8 (3.9%) constipation, in 17 (8.4%) gastro-enteritis and 49 (24.0%) patients had a diagnosis which is generally treated by another specialty (general medicine 17, gynaecology 14 , urology 7).

Imaging (US, CT scan or both) was used in 101 (49.5%) patients with a non-surgical diagnosis. During the study period the proportion of patients undergoing these diagnostic tests decreased significantly (61.5% in group 1 vs. 40.7% in group 2, p=0.003). This result was mainly due to a significant reduction in CT scan requests 38.5% in group 1 and 25.0% in group 2 (p=0.037) (figure 8.2a).

For patients with a non-surgical diagnosis the median length of stay reduced during the study period from 25 hours (7.5-46.8) in group 1 to 19 hours (5.0-19.0) in group 2 (p=0.049). Also, the proportion of patients presenting with a non-surgical diagnosis and who were discharged within 12 hours from surgical assessment, increased significantly (32.3% in group 1 vs. 50.0% in group 2, p= 0.010), figure 8.2b.
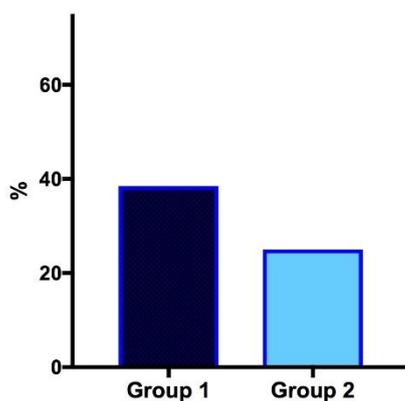
Figure 8.2a CT scans for patients with a non-surgical diagnosis
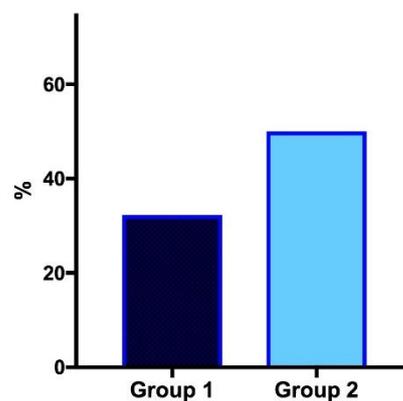
Figure 8.2b Patients with a non-surgical diagnosis discharged <12hours

In univariate analysis of all patients with a non-surgical diagnosis who were identified as requiring urgent management on assessment, had abnormal findings on examination (tachycardia, hypo- or hypertension, raised temperature (>38 °C) and/or peritonism), had an increased white cell count (WCC) and/or C-reactive protein (CRP) or had had additional imaging requested were less likely to be discharged within 12 hours from assessment (table 8.2).

In multivariate analysis only the patients that were considered to have an urgent diagnosis, had abnormal findings during assessment or required imaging to obtain a diagnosis were still significantly associated with a longer length of hospital stay. There was no significant difference for these variables when patients were analysed according to their group (group 1 vs. group 2).

Table 8.2 Patients with non-surgical diagnoses discharged within 12 hours vs later discharges

	Discharge <12 hrs (N = 85)	Discharge >12 hrs (N = 119)	Univariate analysis Odds ratio (95%CI)	p value	Multivariate analysis Odds ratio (95%CI)	p value
Gender (female)	57 (67.1%)	71 (59.7%)	0.73 (0.41-1.30)	**0.281**		
Age (<30 years)	29 (34.1%)	43 (36.1%)	0.92 (0.51-1.64)	**0.766**		
Co-morbidities	41 (48.2%)	61 (52.1%)	1.17 (0.67-2.04)	**0.586**		
Previous abdominal surgery	41 (48.2%)	54 (45.4%)	0.89 (0.51-1.56)	**0.687**		
Referrer (ED)	35 (41.2%)	64 (53.8%)	1.62 (0.95-2.92)	**0.076**	1.26 (0.65-2.42)	**0.499**
Assessment by junior	54 (63.5%)	76 (63.9%)	0.99 (0.55-1.76)	**0.961**		
Assessment during day shift	41 (48.2%)	57 (47.9%)	1.01 (0.58-1.77)	**0.962**		
Abnormal finding examination	8 (9.4%)	42 (35.3%)	5.25 (2.31-11.91)	**<0.001***	2.95 (1.19-7.33)	**0.020***
Urgent on assessment	4 (4.7%)	30 (25.2%)	6.83 (2.31-20.22)	**<0.001***	4.78 (1.43-15.98)	**0.011***
Bloods						
WCC (>12.0 10^9/L)	14 (16.5%)	38 (31.9%)	2.38 (1.19-4.75)	**0.012***	1.65 (0.74-3.71)	**0.225**
CRP (>25 mg/L)	11 (12.9%)	28 (24.1%)	2.14 (1.00-4.59)	**0.047***	1.34 (0.55-3.31)	**0.522**
Imaging (yes)	24 (28.2%)	79 (66.4%)	5.02 (2.74-9.21)	**<0.001***	4.77 (2.47-9.21)	**<0.001***

ED; emergency department, WCC; White Cell Count (10^9/L), CRP; C-Reactive Protein (mg/L).* Significant findings (p ≤0.05)

In the non-surgical group, 24 (11.8%) patients represented within ninety days and this proportion did not differ between group 1 and group 2 (p=0.759). Of these 24 patients, one (52 years old) was discharged with abdominal pain and an unclear diagnosis (blood results within normal rage, not concerning presentation at the day of presentation). An urgent outpatient CT to exclude mild diverticulitis showed uncomplicated appendicitis. The patient had a laparoscopic appendicectomy the day of the CT scan and was discharged the next day. The remaining 23 patients returned with symptoms similar to their initial presentation, the majority went on to have a CT scan or diagnostic laparoscopy, but this did not alter their initial diagnosis of non-specific abdominal pain. None of the patients with a non-surgical diagnosis had a complication within ninety days of discharge.

Patients with a surgical diagnosis

Of the two-hundred-and-fifty (55.1%) patients with a surgical diagnosis the use of additional imaging (US or CT scan) and the length of stay did not differ between the two groups (imaging 70.1 vs. 72.9%, p=0.618 and length of stay 2 (1-5) vs. 2 (1-4.5) days, p=0.478). Thirty-nine patients (15.7%) represented to ED or were re-admitted within ninety days of discharge, this number did not differ between the two groups (p=0.358). A total of 35 complications occurred in 25 (4.6%) patients, 15 in group 1 vs. 10 in group 2 (p=0.177), (table 8.3).

Table 8.3 In-hospital complication summary for patients with a surgical diagnosis

Clavien-Dindo:	n	Explanation
1	10	Ileus, delirium, mild post ERCP pancreatitis
2	18	Wound infection, pneumonia, TPN, AKI, fevers unknown source, UTI
3	5	
4	2	Anastomotic leak, intra-abdominal collection,
		MI, splenectomy due to iatrogenic injury
Total	**35**	

ERCP; endoscopic retrograde cholangiopancreatography, TPN; total parenteral nutrition, AKI; acute kidney injury, UTI; urinary tract infection, MI; myocardial infarction

Acute outpatient CT scan

The new acute outpatient CT scan slot was used for 21 patients. For seven patients the scan was requested due to recurrent presentations with the same pain without abnormal findings on examination or blood results. Six of these scans did not show pathology that could explain the patient's symptoms, one showed uncomplicated appendicitis. Three were used as follow up scans for known intra-abdominal pathology (e.g. appendiceal abscess conservatively managed). Eleven scans were requested for patients with suspected GI cancer, five were positive. All scans were performed on patients who were well enough to be treated as outpatients, but would previously occupy an inpatient bed waiting for a non-urgent CT scan.

Urgent vs. non-urgent differentiation

A total of 120 (26.4%) patients were deemed urgent on assessment and 108 (23.8%) patients were considered urgent based on their final diagnosis.

Of all included patients, 286 (63.0%) were assessed by a junior registrar, compared to 70.8% in the previous prospective cohort of patients explained in detail in chapter 7. Overall sensitivity of recognising the urgent from the non-urgent patient was 69.8%, compared to the sensitivity of 74.7% in chapter 7. The overall specificity was 86.7 compared to 89.9% in the previous cohort Again, accuracy was significantly higher amongst senior registrars, sensitivity 85.8% and specificity 91.0% (p=0.016), (table 8.4).

Table 8.4 Accuracy of identifying urgent patients amongst junior and senior registrars

	Junior (N=287)	Senior (N=167)	Total (N=454)
True positives	49 (17.1%)	25 (15.0%)	74 (16.3%)
True negatives	178 (62.0%)	122 (73.1%)	300 (66.1%)
False positives	34 (11.8%)	12 (7.2%)	46 (10.1%)
False negatives	26 (9.1%)	8 (4.8%)	34 (7.5%)
Sensitivity	65.3%	85.8%	69.8%
Specificity	84.0%	91.0%	86.7%

Junior registrars have < 5 years of post-graduate experience, senior registrar's ≥ 5 years of post-graduate experience.

Patients who had an urgent diagnosis on final assessment, more often required an operation compared to patients who had a non-urgent diagnosis (p<0.001), (table 8.5). Times from assessment to requesting imaging and from requesting imaging to performing the test did not differ between urgent and non-urgent patients (p=0.273 and p=0.335, respectively).

A diagnostic delay (>6 hours from ED presentation to booking an operation) occurred significantly less frequently for patients with an urgent diagnosis compared to patients with a non-urgent diagnosis requiring an

operation (p=0.009 and p=0.003 respectively). There was no significant difference in the proportion of patients having a logistic delay between urgent and non-urgent patients (p=0.787). Overall length of hospital stay was significantly longer for patients with an urgent diagnosis and complications occurred more frequently in this group (p<0.001 for both).

Table 8.5 Comparison between urgent and non-urgent patients for in-hospital waiting times, events and length of stay

	Non-urgent patients (N=346)	Urgent patients (N=108)	p value
Presentation to assessment	3 (2-6)	3 (2-5)	0.032*
ED triage code	3 (3-3)	3 (3-3)	0.169
Imaging (%)	221 (63.9%)	61 (56.5%)	0.167
Assessment to requesting imaging	0 (0-4)	0 (0-4)	0.273
Requesting to performing imaging	3 (1-11)	3 (1-8)	0.335
Operation (%)	44 (12.7%)	96 (88.9%)	<0.001*
Operation category	3 (3-4)	3 (3-3)	<0.001*
Assessment to booking operation	15 (1.3-38.3)	4 (0-13)	0.001*
Booking operation to entering theatre	4 (2-18.5)	3 (1.3-5.8)	0.083
Diagnostic delay	34 (77.3%)	52 (54.2%)	0.009*
Surgical diagnostic delay	31 (70.5%)	42 (43.8%)	0.003*
Logistic delay	11 (25.0%)	22 (22.9%)	0.787
LOS	1 (0-2)	2 (1-5)	<0.001*
Re-presentations (90 day)	49 (14.2%)	14 (13.0%)	0.745
Complications (90 day)	5 (1.4%)	20 (18.5%)	<0.001*

Urgent vs non-urgent differentiation is based on the final diagnosis. Times in hours and length of stay in days, median (IQR). ED; emergency department, LOS; length of stay. * Significant findings (p ≤0.05)

8.4 Discussion

The use of imaging and length of stay for patients with a non-surgical diagnosis significantly reduced after the implementation of a quality improvement system in our institution. This did not lead to an increase in the number of re-presentations or re-admissions.

Surgical vs non-surgical diagnoses

Previous studies have shown increases in the use of additional imaging, mainly CT scan, to aid diagnosis for patients presenting with acute non-traumatic abdominal pain(41, 43, 103). Although the diagnostic accuracy is increased(39, 44), a recent study has shown that routine imaging leads to significantly increased waiting times and costs(46). Therefore, initiatives like 'Choosing Wisely' and pathways using selective imaging have been introduced(73, 89, 133). In addition, in chapter 4 it shows that approximately one-fifth of the scans requested for patients presenting with acute abdominal pain, were not indicated(155).

This study has shown that the use of imaging for patients with non-surgical diagnoses can successfully be reduced with departmental awareness about the overuse of imaging and education of registrars. This reduction should result in a more efficient use of hospital resources and a reduction in length of hospital stay.

In chapter 4, the majority of the CT scans that were deemed to be indicated by the expert panel, were considered non-urgent (24-48 hours). This finding led to the implementation of an acute outpatient scan. It seems to be very useful for the systemically well patients that normally occupy a bed waiting for an inpatient scan, because waiting for an outpatient scan will be too long.

Two-hundred-and-four (44.9%) patients presented with a non-surgical diagnosis, whereas in 2004 the proportion of patients with a non-surgical diagnosis only made up 25% of all presentations(103). This trend is also seen in ED, with an increasing number of patients presenting with relatively benign problems(2-4). It is difficult to explain this increase in presentations and

admissions, it might partially be caused by patient expectations, physicians defensive approach and improved access to health care resources(3). However, this effect should not influence the care of patients presenting with more urgent diagnoses. Early differentiation between surgical and non-surgical patients therefore, is essential.

This study showed that with relatively simple implementations, including: adjusting patient expectations (by providing information about the assessment process), changing the assessment process (having patients sitting in a chair instead of always lying in a bed), educating all surgical staff (nurses, registrars and consultants) and regular updates about management, we were able to significantly increase the number of early discharges (<12 hours) and reduce length of stay for non-surgical patients.

Patients who turned out to have a non-surgical diagnosis, but who looked unwell or had abnormal findings on examination, had raised inflammatory markers (WCC and CRP) and/or were deemed to require additional imaging, were the least likely to be discharged within 12 hours from assessment. Surprisingly, age, gender, existing co-morbidities or previous abdominal surgery did not have an effect on whether the patient was discharged within 12 hours or not. Neither did assessment by a junior registrar (PGY <5) or assessment during the day shift compared to the evening or night shift. This implies that mainly patients that were thought to have more urgent underlying pathology stay longer than 12 hours for observation and additional tests and this is likely to present good clinical practice.

If the reduced length of stay found in this study continued over a year a total of 6,810 in-patient hours would be saved (5 hours reduction in overall length of stay for this cohort of 454 patients over 4 months). The cost of staying in a surgical bed for 24 hours was estimated to cost NZ$ 1,046.33 (without any investigations or medication)(156). The estimated cost reduction over a year from these simple implementations is approximately NZ$297,000. The reduction in the use of CT scans will also add to the cost savings.

The re-presentation and re-admission rates remained unchanged during the study period and were comparable to the re-admission rate from

another prospective cohort study in our institution(154). Furthermore, no important diagnoses were missed that resulted in delayed treatment for the patient. The patient that turned out to have appendicitis had an organised urgent outpatient scan, because they had an atypical presentation and the time from initial assessment to appendicectomy was still less than 24 hours. This implies that patients who are thought to have a non-surgical diagnosis on assessment can be safely discharged within 12 hours. A senior review might be required when a junior registrar feels unsure about making this decision.

When additional imaging is more selectively used for patients with presumed non-surgical diagnoses and when length of hospital stay can be reduced for this group it will not only have cost implications but should have clinical implications as well. The clinicians focus should shift to patients with a surgical diagnosis, resulting in improved general care for this patient group, faster access to additional diagnostic tests and ultimately should result in a reduction in the complication rate and length of hospital stay. This should be further evaluated in a prospective study appropriately powered to assess the differences in these final outcomes.

Urgent vs. non-urgent diagnoses

The overall sensitivity and specificity in recognising the urgent from the non-urgent patients was similar to the previous cohort (chapter 7). The comparisons were on the basis of the final diagnosis, not the initial assessment. As the initial assessment is dependent on the level of experience of the doctor assessing the patient and the patient's presentation (as in chapter 7). Waiting times between assessment and booking imaging and booking and performing imaging did not differ between urgent and non-urgent patients. This implies that prioritising patients as urgent did not result in faster access to additional imaging. The timeframes, however, are relatively short for both groups of patients.

Urgent patients more often required an operation compared to non-urgent patients. A diagnostic delay occurred in 61.4% of all patients which is comparable to 66.5% of the patients in chapter 5(157). A diagnostic delay

occurred significantly less frequently for patients that were deemed urgent on assessment compared to patients that were thought to have a non-urgent diagnosis (p=0.009).

A logistic delay occurred in 23.5% compared to 31.0% for the cohort explained in chapter 5. This difference is most likely related to the differences in the cohorts explained before. A logistic delay occurred as frequently for patients that were thought to have an urgent diagnosis as to patients with a non-urgent diagnosis (p=0.787)(157).

Both delays are associated with increased risk of morbidity and mortality (137, 157). Reducing both delays, especially for patients with an urgent diagnosis, should result in improved care for this critical patient group, including a reduction in complication rate, mortality and length of hospital stay. This emphasizes the necessity of differentiating patients between urgent and non-urgent during the assessment and aiming to optimise care for patients presenting with an urgent diagnosis.

Limitations

When length of stay and use of imaging is reduced for patients presenting with non-surgical diagnoses is reduced, it should result in faster access to hospital resources for patients with surgical diagnoses. Ultimately, this should lead to a reduction in morbidity and mortality for the latter group. The current study was unable to observe this and this is most likely related to the sample size of the cohort.

The assessment (urgent vs. non-urgent) and findings on examination, were dependent on the registrar and his/hers experience. The decision to call registrars senior when they had more than five years of post-graduate experience is partially arbitrary and partially based on when registrars usually enter the general surgery training programme in Australasia and the increased responsibilities associated with that (see chapter 7).

Patients who were thought to have an urgent diagnosis waited as long as patients who were deemed non-urgent on assessment for additional imaging.

Although times to obtaining the tests overall were relatively short, it still highlights the gaps in communication between the departments of general surgery and radiology when requesting a scan.

Patients that were deemed urgent on assessment had a logistic delay as frequently as patients that were deemed non-urgent. These results and the results from chapter 5 highlight the need for better theatre access to improve patient care in our institution.

8.5 Conclusion

This study showed that with relatively simple quality improvement implementations the number of CT scans and length of hospital stay for patients with non-surgical abdominal pain can be significantly reduced. This will have obvious cost implications, but should also result in a better focus on patients with more urgent diagnoses which should lead to improved outcomes for these more critical patients. As explained previously, this study has been unable to prove an improvement in the final outcomes for patients presenting with a surgical diagnosis. This is most likely related to the cohort size.

Chapter 9: Conclusions and future research directions

9.1 Conclusions

Abdominal pain is a common presenting complaint to ED and has remained a challenging clinical complaint despite multiple innovations that aimed to improve the diagnostic process(39, 44, 51, 52, 66, 76). With the introduction of the CT scan, high diagnostic accuracy can be achieved and this has resulted in a reduced incidence of patients being diagnosed with NSAP(3, 4). On the other hand, this high diagnostic accuracy comes with significant downsides, including; radiation exposure, contrast induced nephropathy, allergic reactions to contrast, increased waiting times and hospital costs(46). Furthermore, the increased diagnostic accuracy does not seem to have an effect on final outcomes like length of stay, morbidity and mortality(44). Optimising the assessment of patients presenting with abdominal pain and the use of diagnostic tests would results in more efficient use of health care resources, reduced length of hospital stay and ultimately improved patient care.

The first study in this thesis aimed to review the diagnostic process and the use of additional imaging for patients presenting to general surgery with acute abdominal pain over the last decade in Wellington Hospital. This study found that from 2004 to 2014, the number of acute surgical admissions increased substantially. There was an increase in the use of CT scans, but more of these were negative for acute pathology. Furthermore, a greater proportion of patients admitted under general surgery had a non-surgical diagnosis(103). These observations suggested that there was need to carefully assess the processes by which patients are admitted and investigated.

The most common diagnosis requiring urgent intervention for a patient presenting with acute non-traumatic abdominal pain, is appendicitis. To evaluate what the effects have been of the increased use of diagnostic tools (e.g. CT scans) and the implementations to improve patient assessment (6-hour ED target and ASU), a follow up study was designed. This study aimed to assess the effect of these implementations to patients undergoing an acute

appendicectomy and to evaluate the NAR. There was a statistically significant decrease in the NAR between 2004 and 2009, although it is possible that the 2004 rate was not fully representative. However, between 2009 and 2014 the NAR was unchanged despite an increase in the use of CT scans in that time period(126). Imaging for this group is, however, still used selectively. Internationally studies show that universal use of imaging has been associated with a significant decrease in the NAR(109), but whether this benefit weighs up against the downsides of a substantive increase in the use of CT imaging remains unclear. Therefore the question remains, what NAR is acceptable while using selective imaging.

The first two studies observed an increase in the use of CT scans to aid the diagnostic process for patients presenting with acute abdominal pain, but also observed an increase in the proportion of scans that are negative for acute pathology. The next study was designed to evaluate the clinical indication for a CT scan for this patient group. Five radiology consultants and five general surgery consultants were asked to review a hundred consecutive CT scans requested for patients presenting with acute abdominal pain. This study showed that both specialists agreed that in approximately one fifth of the requests, no CT scan was indicated. Based on these results it seems that a more critical review may be required prior to ordering CT scans for patients presenting with acute abdominal pain, particularly in younger patients and those with a presumed non-surgical diagnosis. This will result in a more optimal use of hospital resources(155).

Another important finding in the first two studies was the observed increased waiting time for patients requiring an acute operation. This was therefore the focus of an in-depth analysis that evaluated the patient's progress from acute presentation to arrival in the operating theatre and to identify where delays occur. Previous studies have identified two types of delays for this patient group. A diagnostic delay, between presentation of the patient and booking them for their operation and a logistic delay which occurs between booking a patient and when the patient actually arrives in theatre. The first is defined as a delay when the diagnostic process takes longer than 6 hours, as previous literature has identified that this is associated with poorer patient

outcomes(60, 61). The logistic delay is dependent on the booking acuity. The results of the study showed that a diagnostic delay occurred in 55.1% of the patients and was more frequently observed in patients referred via the ED, booked as a category 3, who presented out of hours and/or who required imaging prior to their operation. A logistic delay occurred in 31.0% and was more frequently observed in patients booked as a category 3 and those who were booked out of hours. Delays (both diagnostic and logistic) have been associated with poorer outcomes for the patient(137). Therefore, this study concluded that addressing both types of delays is essential to optimise patient safety.

The previous studies clearly highlight the difficulties in the assessment process for a patient presenting with abdominal pain. A diagnostic pathway can be helpful to aid the clinical team in deciding who may need diagnostic tests and who can be observed or even discharged. The aim of the performed systematic review was to identify the current evidence for diagnostic pathways for this patient group and what their effect is on final outcomes including length of stay, morbidity and mortality. This review included 10 studies, all describing a different pathway. Most of the pathways included routine imaging, but the majority of these pathways were not prospectively evaluated. Also, none of the included studies reported a reduction in any of the final outcomes. On the basis of this systematic review we can conclude that none of the pathways described could be readily implemented to aid the assessment process for patients presenting with abdominal pain(141).

With regards to the systematic review and previous studies, it was decided to make changes in the assessment process. Some studies described a differentiation between urgent and non-urgent patients and base the rest of the decision making on this differentiation(37, 39). However, to date there is no evidence whether this differentiation can be accurately performed by registrars. Therefore, the aim of the first prospective study was to evaluate whether this differentiation could be accurately made for patients presenting with abdominal pain prior to the use of advanced imaging. Urgent patients were defined as requiring operative, endoscopic or radiologic management or ICU support within 24 hours. The study showed that our registrars could accurately identify the

urgent from the non-urgent patient presenting with acute abdominal pain, although senior registrars are more accurate compared to junior registrars. These results implies that a prioritisation prior to the use of additional diagnostic tests was practical and safe.

A quality improvement program was introduced to the department aiming to optimise the early differentiation for patients presenting with abdominal pain and to encourage early discharge for patients presenting with non-surgical diagnoses. It also aimed to improved use of hospital resources for patients with a suspected non-surgical diagnosis. Optimally it was thought that if these aims were achieved it should improve access to hospital resources for patients presenting with a surgical diagnosis.

The study showed that the intervention resulted in an increase of the proportion of patients with non-surgical problems that were successfully discharge within 12 hours and reduced use of additional imaging (mainly CT scans) in this group. Furthermore, the re-presentation rate remained unchanged and no serious diagnoses were missed. The study showed no improvement in morbidity and mortality for patients presenting with a surgical diagnosis. This is thought to be due to the relatively small sample size and the fact that the incidence of morbidity and mortality is relatively rare in an average surgical cohort.

From this thesis it is obvious that there were issues in the assessment process for patients presenting with abdominal pain, which resulted mainly in increased admission rates for patients with non-surgical diagnoses and increased use of imaging for this group. When implementing a quality improvement program for the department of general surgery in Wellington Hospital, use of imaging and length of stay for patients with non-surgical diagnoses was successfully and safely reduced. These KPI's should be audited continuously to optimise patient care and efficiency within the department of general surgery and to further improve it. This will have obvious cost implications, but should also result in improved care for patients with more urgent diagnoses. Ultimately, this should lead to reduced incidence of morbidity and mortality and length of stay for this more critical group of patients.

9.2 Limitations

There are limitations to the studies included in this thesis. More than half of the patients referred to general surgery are referred via ED. This study did not include the ED assessment and did not include the time spent in ED for the calculations in chapter 8. Waiting and assessment times in ED are variable and very dependent on the level of experience of the assessing clinician and ED waiting room pressure. Furthermore, patients that were assessed and discharged by ED were not included. Changes in ED behaviour over time has contributed to the increase in non-surgical patients being admitted under general surgery. Understanding the factors that contribute to this is important. However this was beyond the scope of any of the included studies.

These limitations are also applicable to patients who are referred via their GP. Both groups of patients go through an assessment prior to the surgical assessment and the delays in this primary assessment are difficult to quantify. Although GP's generally don't have the same access to laboratory tests and X-rays as the ED or SAPU. Currently there is a low threshold for GP to refer patients directly to SAPU for a surgical assessment. Although this means that a substantial proportion of the patients present with non-surgical abdominal pain, it probably needs to remain a low threshold in order to not miss acute patients who present atypically.

It is very likely that a Hawthorne effect has influenced some of the outcomes. The Department of General Surgery was informed about each study's results. For the last project a monthly update about early discharges and length of stay was scheduled and would have increased awareness, and may well have altered the behaviour of clinical staff.

The Department of Radiology was included in two studies (chapter 4 and 8). They were keen to cooperate and address the issue of the increasing number scans requested for patients with non-surgical diagnoses. They may have played a role in the observed reduction of CT scans requested for this patient group which is presented in chapter 8, by reviewing request more critically.

Lastly, this study (chapter 8) was underpowered to evaluate the effect of the implementations to final outcomes for patients with surgical diagnoses. It is expected that the implementations will result in improved care for this patient group, but to date we cannot objectively demonstrate this.

9.3 Future Research

To address the diagnostic delay for patients referred via ED, because this patient group is generally more unwell compared to patients referred via the GP. It would be interesting to observe what the consequences are when a general surgery registrar with a reasonable level of surgical experience (PGY >4) is in ED to help the early assessment and prioritisation of patients presenting with abdominal pain. The hypothesis is that this would reduce the diagnostic delay, increase early discharges for non-surgical patients and improve final outcomes of the patients.

This study design is controversial, because ED specialists have been introduced to improve the care of patients presenting with acute problems to the hospital and also to optimise early differentiation between specialties. However, for patients requiring an admission it results in a double assessment, with associated delays. This is for difficult diagnostic issues such as patients presenting with abdominal pain often the case. Diagnoses are, due to lacking experience, under or overestimated and with that the primary assessment by ED may cause more harm than benefit. Whether, this study would be feasible remains open for discussion.

One of the ongoing aims of the department of general surgery in Wellington Hospital is to introduce a full day general surgery acute theatre list. Achieving this should result in a reduction in patients experiencing a logistic delay. When this list is implemented a new study should be introduced assessing times to theatre and reasons for delays. This should be a prospective study, because some delays are difficult to objectify retrospectively.

The results presented in chapter 8 are the first results after introducing the quality improvement program. The effects of this program on the KPI's: use of imaging, length of stay for non-surgical patients, final outcomes for surgical patients and re-admission rates should be further monitored to review the effect of the implementations over time and with a larger cohort.

Another challenge could be to introduce the implementations described in chapter 8 and compare their effect in a different surgical department or even in multiple institutions. Because the issues with the diagnostic process of

patients presenting with abdominal pain do not seem to be specific to Wellington Hospital, but are anecdotally reflected in more institutions in New Zealand and possibly outside New Zealand.

Furthermore, this study showed a trend in cost reduction secondary to the implementation of the quality improving initiative. A more detailed annual cost implications survey would be necessary to assess the total cost reduction. This should not only include bed costs but also use of additional resources like CT scanning.

Finally, in this thesis we did not address the patient perspective of the new implementations. It would have been interesting to compare patient satisfaction before and after the implementation of the quality improvement program. While it may be safe and cost-effective to discharge non-surgical patients rapidly, it is important that the patient perception of their care remains high.

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Appendices

Appendix 1 Surgical assessment note

Capital & Coast
District Health Board
ŪPOKO KI TE URU HAUORA

Surgical Assessment Note
(Surgical Assessment Note)

MR LESLIE JOHN COCHRAN
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⊟ **Assessment**

Admitting Consultant

Admitting RMO

Contact Number

Past Medical History

Current Medication

Allergies

Last Meal

Current History

Examination

Relevant Results

Bloods

Urine

Imaging

Impression *

Priority

Urgent patients are defined as requiring treatment (ICU support, theatre, endoscopic management or radiologic drainage) within 24 hours.

* ○ Urgent   ○ Non-urgent

Plan

○ Admit   ○ Discharge

Medication

☐ IV Fluids   ☐ IV Antibiotics   ☐ Oral Antibiotics

☐ Anti-emetics   ☐ Analgesia   ☐ DVT prophylaxis

Urinary Catheter   ○ Yes   ○ No

Fluid Balance   ○ Yes   ○ No

Diet   ○ NBM   ○ Clear fluids   ○ Free fluids   ○ Light diet   ○ Normal diet

Appendix 2 Poster SAPU

Surgical Assessment & Planning Unit

Welcome to SAPU

You are here for an assessment. This means that:

- you will be seen by both doctors and nurses
- you maybe require a blood test, urine test or an X-ray.

When we have all the results back we will decide whether:

1. you can go home, maybe with a prescription and/or outpatient follow up
2. you need further tests
3. you need to be admitted to the hospital because you need medication via a drip or you may even need an operation.

Please make yourself comfortable while you are in the assessment room.

Please do not drink or eat anything, as some tests have to be done with an empty stomach. Your doctor or nurse will tell you when you can have something to eat and drink.

Please ask your nurse if you require further assistance, if you need more pain relief or if you have any questions.

Capital & Coast
District Health Board

COMMS-0101-1709 - October 2017

Appendix 3 SAPU detailed information leaflet

Surgical Assessment & Planning Unit (SAPU) – Short Stay & Assessment Beds

Patient Information

Capital & Coast District Health Board
ŪPOKO KI TE URU HAUORA

SWCD

Welcome to SAPU. SAPU is located in Ward 7 South pod F. It has two assessment beds, 8 short stay beds and a waiting room.

You have been admitted to the short stay area of SAPU from either your GP, the Emergency Department (ED) or the SAPU assessment bay. If you need to stay overnight, it is expected that you will stay in SAPU for less than 48 hours. If you need a longer stay you will be moved to one of the longer term wards.

SAPU waiting room

This waiting area has 4 armchairs. You may be asked to wait here before and/or after your assessment. Whilst you are waiting we will gather results from additional tests (blood, urine or scans). When these results are available they will be discussed with you. A decision will then be made as to whether you need to be admitted or whether you can go home.

A separate information sheet giving more will be available when you arrive in SAPU. Information can be also found on the posters on the wall.

General Information

- *Call Bell*-If you need a nurse use the green call button on your handset
- *Visiting hours* are 8am-9pm, please ask your nurse if you need to have visitors outside the standard visiting hours for any special reason.
- *Access to SAPU* is by the orange lifts to level 7 south.
- *Smoking*- all of CCDHB is a smoke free site inside and outside. We can offer support to quit through our smoking cessation service. Please ask your nurse if you are interested

- Overnight facilities- There are no overnight stay facilities on SAPU for the family of the patient. Please see the nursing staff if an overnight stay is required, or if you live out of the area.

What other procedures may be required?

X-ray -you may be required to have an x-ray in the radiology department- sometimes for this you need to have a contrast drink to improve the image that is being x-rayed.

Computed Tomography Scan (CT) – Is medical imaging that can give a more detailed image than an X-ray. When you have a CT scanning you must have had nothing to eat for 6 hours and no fluid for 2 hours. You may be asked to drink 2 or 3 glasses of a solution to help improve the image being scanned. If this is needed your nurse will give you this before your procedure. If you need to have a CT scan more detailed information.

Ultrasound scan (USS) –Ultrasound is a safe and painless procedure that doesn't use X-rays. High-frequency sound waves and their echoes are used to create images (or scans) of the inside of your body. The images are black, white and grey and are usually displayed on a TV screen. Sometimes you will need to have a full bladder or not eat before your USS. The staff will tell you if this applies to you.

Operating Theatre (OT) –If you need to have an operation your doctor will give you a full explanation and answer your questions. Before going to the operating theatre you will be seen by an anaesthetist. This may be in SAPU or in the theatre department holding bay before going into theatre. If you have an operation you will not

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[continued]

return to SAPU. You will go to either Second Stage Recovery (SSR) or one of the other wards. Your belongings will be taken there while you are in OT.

What happens on discharge from SAPU?

When you are discharged your discharge paper work and prescription (if necessary) will be ready for you. If you need a medical certificate please ask your nurse or doctor.

Make sure that before you leave the hospital you have a full understanding the new medication prescribed (when to take it and for how long, etc.) and of follow up plans and appointments, if applicable. Your nurse or doctor can clarify both to you.

The expected time of discharge at Wellington Hospital is 11am. If you are not able to be collected until after 11am there is a transit lounge where you will be able to wait. Your nurse will direct you to it.

What if I need to stay in hospital longer than 48 hours?

If you are unable to be discharged from SAPU after 48hrs you will usually be transferred to Ward 7 North (general surgical ward) located at the opposite end of the corridor or Ward 6 North (urology and orthopaedic). These are both 44 bed wards for patients who have undergone surgery or patients who require a longer hospital stay.

I am discharged and I still have some unanswered questions or on-going symptoms?

When you are discharged from SAPU you may be given a 'blue card'. This has SAPU contact details on it. If you have any unanswered questions you can contact the SAPU to speak to a nurse. If you have any further questions, or on-going symptoms and want to see a doctor please go to the emergency department taking the 'blue card' with

you. The emergency staff will contact SAPU and will be transferred back to SAPU (when possible) and you will not have to wait longer in the emergency department. This card is valid for 48 hours.

If you have not been given a 'blue card' or have medical questions not related to your recent visit to SAPU your first point of contact is your General Practitioner or in case of an emergency, the Emergency Department.

Contact us

Surgical Assessment & Planning Unit (SAPU)

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