EFFECTS OF PERIOPERATIVE HYPEROXYGENATION ON SURGICAL SITE INFECTION IN PATIENTS WITH ACUTE APPENDICITIS

By

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In partial fulfilment of the requirements for the award of the degree of

MASTER OF SURGERY

IN

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UNDER THE GUIDANCE OF

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ABSTRACT

INTRODUCTION

Surgical wound infection is nightmare for any surgeon following elective and emergency operations. In recent studies, the possibility of reducing Surgical site infection(SSI) by perioperative hyperoxygenation has been raised. Hypoxia at the level of local wound site retards proper healing. Proper oxygenation of the tissue through microcirculation is vital for the healing process and for resistance to infection. The data obtained from the related randomized, controlled trials for the benefits of perioperative hyperoxygenation to reduce SSI remain controversial. To overcome this problem, we have performed a randomized, controlled trial in a patient population with a single diagnosis (acute appendicitis), using standard surgical approach (open appendicectomy).

AIMS AND OBJECTIVE

To know the effects of hyperoxygenation on surgical site infection following open appendicectomy in the patient having acute appendicitis in forms of ASEPSIS criteria, duration of hospital stay and cost effectiveness.

MATERIAL AND METHODS

This was a prospective case control study conducted at BLDEU's shri B. M. Patil Medical College Hospital and Research Centre, Vijayapur from Oct 2015 to Aug 2017 and included 180 patients with Acute appendicitis and in each group 90 patients were allotted. A total of 180 patients who underwent open surgery for acute appendicitis, Preoperative intravenous antibiotics were given to all patients. In the control group, 90 patients received oxygen from the room air, while in the study group, the fraction of inspired oxygen(FIO_2) reached 80% with the use of nonrebreathing mask in the rest 90 patients and continued for 2 hours in the recovery room following completion of the operation in the study group with high-flow oxygen (10 L/min) through a nonrebreathing mask, while control group received oxygen from room air. We used the ASEPSIS system score to assess the degree of healing and infection of the surgical wound. The results of the two groups were compared and analyzed.

RESULTS

The post operative SSI according to ASESPIS criteria, mean hospitalization, use of antibiotics and cost effectiveness were assessed and P values derived and compared between the two groups. In our study we noticed marked difference in requirement of antibiotic in control group (98.9%) as compare to study group (1.1%) making it significant. In study group 5 (5.6%) patients had surgical site infection while in control group 17 (18.9%) patients had surgical site infection as per ASEPSIS score. Control group has average stay of 7.6 ± 2 days while study group has 6.4 ± 2.4 days which is statistically lower in study group. Cost of treatment in study group is significantly lower than the control group.

CONCLUSION

The use of perioperative hyperoxygenation is advantageous in operations for acute appendicitis. As this is the most common emergent operation in general surgery, decreasing the rate of SSI carries significant clinical and economical gains in the form of judicious use of antibiotics, shorter hospital stay and cost effectiveness. In addition, as our study was conducted in a relatively homogeneous study population, our results support the beneficial effects of supplemental oxygen in clean contaminated surgery in general.

KEY TO WORDS: Acute appendicitis, Open appendicectomy, Hyperoxygenation, Surgical site infection, ASEPSIS score.

LIST OF ABBREVATIONS

SSI	Surgical site infection
HCAIs	Healthcare associated infections
RQ	Respiratory quotient
FiO_2	Fraction of inspired oxygen
HIV	Human Immunodeficiency Virus
HB	Haemoglobin
IV	Intravenous
IM	Intramuscular
DM	Diabetes Mellitus
O_2	Oxygen
HBO	Hyperbaric oxygen therapy
VAC	Vacuum assisted closure
USG	Ultrasonography
CT	Computed tomography
MRI	Magnetic resonance imaging
HPE	Histopathological examination
FRC	Functional residual capacity
MV	Minute volume
SD	Standard deviation
SILS	Single incision laparoscopic surgery
ASA	American society of Anaesthesiologists
ACR	American college of radiology
CDC	Centers for disease control and prevention

NNIS	National nosocomial infections surveillance
ACS-NSQIP	American college of Surgeons national surgical quality improvement program

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INTRODUCTION

Surgical wound infection is nightmare for any surgeon. Surgical team takes all the precautions before, during and after the surgery to avoid and control the surgical wound infections. In spite of our efforts surgical site infection constitutes a noteworthy problem in emergency and planned surgeries. Among nosocomial infection surgical wound infection is the most common. The postoperative infection rate depends on many factors. Surgical wound infection is associated with increase morbidity, considerable prolongation of the hospitalization period and with the related economic aspects. The cause of surgical wound infection is multi factorial depending on the overall well-being of the patient, types of surgery, surgical skill and use of other preventive measures like prophylactic antibiotics. Other factors which may influence SSI include operative time, core body temperature, postoperative pain and tissue hypoxia.

Hypoxia at the level of local wound site retards proper healing. Proper oxygenation of the tissue through microcirculation is vital for the healing process and for resistance to infection. In recent studies, the likelihood of surgical wound infection by perioperative hyperoxygenation has been raised, but the data obtained from the related randomized, controlled trials remain controversial. In 3 studies, perioperative inhalation of an oxygen-enriched (80%) mixture led to significant reduction of surgical wound infection following miscellaneous or only lower gastrointestinal tract surgery. However, in another 3 randomized, controlled studies concerning various gastrointestinal tract, colorectal or gynaecological operations, perioperative hyperoxygenation was not associated with an improved rate of wound infection. However, in meta-analyses gathering almost all of the participating subjects cumulative results favor the use of hyperoxygenation for surgical wound infection reduction.

Survival is impossible without oxygen. In Atmosphere the concentration of the oxygen is 21%. When we are planning for the hyperoxygenation, it should be treated as drug; it should be prescribed in writing, with the required flow rate and the method of delivery clearly specified. When we are correcting hypoxaemia (PaO_2>8 kPa), we need to observe for hypoventilation and carbon dioxide retention, because both the conditions are unacceptable in clinical practice. In the studies of perioperative hyperoxygenation, oxygen is supplied to the patient who is normally maintaining arterial oxygenation (Pao2 >8kPa, Spo2 >90%) breathing the room air.

NEED FOR THE STUDY

Many studies were done to evaluate the effect of perioperative hyperoxygenation in different types of surgeries. Results of these studies showed variable results. One of the major reasons for such mixed results may be that previous trials have entered a heterogeneous population of patients and procedures, which may have precluded the discovery of small but important differences. To overcome this problem, we performed a randomized, controlled trial in a patient population with a single diagnosis (acute appendicitis), using standard surgical approach (open appendicectomy through McBurney incision). In addition, as it is the most common emergent operation in surgery, reducing the SSI rate and convalescence time following acute appendicitis may carry the most significant economic gains.[1]

AIM AND OBJECTIVE OF THE STUDY

Primary

To evaluate the effects of hyper oxygenation on SSI following open appendicectomy in patients having acute appendicitis.

Secondary

To study difference in

- Duration of Hospital stay
- Cost

REVIEW OF LITERATURE

More than 300 million people undergo surgical procedures each year around the world.[2] This represents twice the number of babies born every year! Thus, millions of individuals are at risk for complications resulting from surgery if correct actions and prevention strategies are not applied at appropriate times. Surgical site infection (SSI) is a leading cause of healthcare-associated infections; it is associated with high mortality, prolonged duration of hospital stay, and high use of additional resources.[3] Yet, with a solid infection prevention and control program, many of these infections are preventable. The global volume of surgery is increasing and is estimated to have increased by ∼38% in the past eight years.[2] The largest increases in rates of surgery took place in very-low and low-expenditure countries.[2] The global burden of SSI is important worldwide, yet this burden seems to affect low-income countries disproportionately, with almost three-fold higher SSI rates than in high-income countries.[4,5] Intensifying infection prevention and control measures, especially in low-income countries, thus becomes paramount.

Surveillance of SSI should be a priority for infection control programs, even in resource-limited settings.

With increasing awareness globally, there are encouraging results showing decreased crude SSI rates over the years; the observed reductions were, however, non-significant. This highlights once more the importance of considering multiple parameters in reports and analyses of surveillance time trends.

The question of high fraction of inspired oxygen as a potential preventive intraoperative measure to reduce the incidence of SSI is controversial, with conflicting results in the literature. A recent Cochrane review had found that there was insufficient evidence to recommend routine use of perioperative high fraction of inspired oxygen.[6] In this issue, Yang and colleagues report results from a meta-analysis suggesting that there may be a reduction in SSI when using high fraction of inspired oxygen intraoperatively.[7] We believe that the jury is still out, and that further high-quality studies are required. Additional studies are also needed to evaluate the question of the effect of postoperative hyperoxygenation on the incidence of SSI.

It would not be possible to discuss infection prevention in surgery without mentioning hand hygiene. The World Health Organization's (WHO) 'Save Lives: Clean Your Hands' global May 5th, 2016 annual call to action for healthcare workers focused on 'improving hand hygiene practices in all surgical services through the continuum of care, from surgical wards to operating theatres, to outpatient surgical services.[8] Thus SSI prevention is multi-modal, calls for multi-parametric and multi-disciplinary actions, and is also extremely challenging.

WHO has given guidelines and suggested multiple measures to control SSI. Perioperative hyperoxygenation is one of the measures to control SSI. Appendicectomy is one of the commonest surgery done all over the world on gastrointestinal tract. For this reason we selected to study the effect of perioperative and postoperative hyperoxygenation on appendicectomy wound.

- In 2009, Qadan M, Akça O, Mahid SS, Hornung CA, Polk HC Jr[1] conducted a meta-analysis of randomized controlled trials to evaluate perioperative supplemental oxygen therapy and surgical site infection concluded that perioperative supplemental oxygen therapy exerts a significant beneficial effect in the prevention of SSI. They recommended its use along with maintenance of normothermia, meticulous glycemic control and preservation of intravascular volume perioperatively in the prevention of SSI.[9]

- In 2011, Bickel A, Gurevits M, Vamos R, Ivry S, Eitan A[2] conducted a study to evaluate perioperative hyperoxygenation and wound site infection following surgery for acute appendicitis concluded that the use of supplemental oxygen is advantageous in operations for acute appendicitis by reducing surgical site infection rate and hospital stay.[1]
- In 2012, Schietroma M, Carlei F, Cecilia EM, Picciione F, Bianchi Z, Amicucci G[3] conducted a study to evaluate the effects of perioperative supplemental oxygen administration on the anastomotic dehiscence in cases of colorectal intraperitoneal anastomosis concluded that supplemental 80% FiO_2 during and during 6 hours after major rectal cancer surgery reducing postoperative anastomotic dehiscence.[10]
- In 2013, Hovaguimian F, Lysakowski C, Elia N, Tramer MR[4] conducted a study to evaluate effect of intraoperative high inspired oxygen fraction on surgical site infection, post operative nausea and vomiting and pulmonary function concluded that intraoperative FiO_2 further decreases the risk of SSI in surgical patient receiving prophylactic antibiotic.[11]
- In 2014, Von Bormann B, Suksompong S, Weiler J, Zander R[5] conducted a study to evaluate pure oxygen ventilation during general anaesthesia does not result in increased post operative respiratory morbidity but decreases surgical site infection concluded that pure oxygen ventilation during general anaesthesia is harmless and reduces clinical morbidity such as post operative hypoxia and surgical site infection.[12]

- In 2014, Schietroma M, Cecilia EM, Sista F, Carlei F, Pessia B, Amicucci G[6] conducted a study to evaluate high concentration supplemental perioperative oxygen and surgical site infection following elective colorectal surgery for rectal cancer concluded that supplemental 80% FiO_2 reduces post operative surgical site infection with few risks to the patient and little associated cost.[13]
- In 2016, Yang W, Liu Y, Zhang Y, Zhao QH, He SF[7] conducted a study to evaluate the effect of intra-operative high inspired oxygen fraction on surgical site infection: a meta-analysis of randomized controlled trials and concluded that there is moderate evidence to suggest that administration of high FiO2 to patients undergoing surgery, especially colorectal surgery, reduces the risk of SSI. Further studies with better adherence to the intervention may affect the results of this meta-analysis.[14]
- In 2016, Schietroma M, Cecilia EM, De Santis G, Carlei F, Pessia B, Amicucci G[8] conducted a study to evaluate supplemental Peri-Operative Oxygen and Incision Site Infection after Surgery for Perforated Peptic Ulcer: A Randomized, Double-Blind Monocentric Trial and concluded that Supplemental 80% FiO2 during and for 6 h after open surgery for PPU, which reduces post-operative SSI, should be considered part of ongoing quality improvement activities related to surgical care, with few risks to the patient and little associated cost.[15]
- In 2013, Stall A, Paryavi E, Gupta R, Zadnik M, Hui E, O'Toole RV[9] conducted a study to evaluate perioperative supplemental oxygen to reduce surgical site infection after open fixation of high-risk fractures: a randomized controlled pilot trial and concluded that use of a high concentration of FIO2

during the perioperative period is safe and shows a trend toward reduction of surgical site infection in patients undergoing open operative fixation of high-energy traumatic lower-extremity fractures. Further study in a larger patient population is indicated.[16]

- In 2009, Al-Niaimi A, Safdar N[10] conducted a study to evaluate supplemental perioperative oxygen for reducing surgical site infection: a meta-analysis and concluded their analysis showed that supplemental perioperative oxygenation is beneficial in preventing SSI in patients undergoing colorectal surgery. Because of heterogeneity in study design and patient population, additional randomized trials are needed to determine whether this confers benefit in all patient populations undergoing other types of surgery. Supplemental perioperative oxygenation is a low-cost intervention that we recommend be implemented in patients undergoing colorectal surgery pending the results of further studies. Further research is needed to determine whether or not supplemental hyperoxia may cause unanticipated adverse effects.[17]
- In 2009, Maragakis LL, Cosgrove SE, Martinez EA, Tucker MG, Cohen DB, Perl TM[11] conducted a study to evaluate the intraoperative fraction of inspired oxygen is a modifiable risk factor for surgical site infection after spinal surgery and concluded that this study identified intraoperative administered fraction of inspired oxygen of less than 50% as an independent, modifiable risk factor for SSI after spinal surgery. Intraoperative administration of at least 50% fraction of inspired oxygen should be tested prospectively as an intervention to prevent SSI after spinal surgery.[18]
- In 2008, Hopf HW, Holm J[12] conducted a study to evaluate hyperoxia and infection and concluded that surgical wound infection remains a common and

serious complication of surgery. Patient factors are a major determinant of wound outcome following surgery. Co-morbidities clearly contribute, but environmental stressors as well the individual response to stress may be equally important. In particular, wounds are exquisitely sensitive to hypoxia, which is both common and preventable. Perioperative management can promote postoperative wound healing and resistance to infection. Maintaining perfusion and oxygenation of the wound is paramount. Once perfusion is assured, addition of increased inspired oxygen substantially reduces surgical site infection in at risk patients. A greater degree of hyperoxemia, achievable with administration of hyperbaric oxygen, is useful as an adjunct to the treatment of serious soft tissue and bone infections in selected patients.[19]

ROLE OF OXYGEN IN BODY

While the exact way oxygen works in the wound healing process is not entirely understood, it's widely recognized oxygen plays a role in nearly every part of the wound healing stages. When the body experiences a wound, it develops an increased need for bacterial defense, cell proliferation, collagen synthesis and angiogenesis, among other reparative functions. Oxygen's main function lies in its capacity to produce energy. In order for cells to properly reproduce and migrate, they must have a sufficient amount of energy. Like all functions involved in the human biology, they require oxygen to be able to generate energy. When an area of the body does not receive an adequate amount of oxygen, a condition known as hypoxia, it can slow and even halt the healing process.

OXYGENATION

In our study we are providing hyper oxygenation to the patient to increase surgical wound site saturation. So its better we understand the basic physiology of oxygen supply in our body.

Normal atmospheric air which we breath is made up of 21% oxygen, 78% nitrogen and small quantities of CO_2, argon and helium. The atmospheric air has a total pressure of 101kPa (1 atmosphere of pressure = 760mmHg =101kPa). Actual pressure of the oxygen (PO_2) of dry air at sea level is therefore 21.2kPa (21/100 x 101 = 21.2kPa).[20] When we inspire humidification and warming in upper respiratory tract modifies the PO_2. At core temperature of 37°C the water vapour pressure in the trachea is 6.3kPa. So the PO_2 in the trachea when breathing air is (101-6.3) x 21/100 =19.9kPa. By the time the oxygen has reached the alveoli the PO_2 has fallen to about 13.4kPa.[21] This is because the PO_2 of the gas in the alveoli (PaO_2) is further reduced by dilution with carbon dioxide entering the alveoli from the pulmonary capillaries. The PaO_2 can be calculated using the

alveolar gas equation: $$PaO_2 = FiO_2 - \frac{PaCO_2}{RQ}$$

Where RQ = the respiratory quotient, the ratio of CO_2 production to O_2 consumption, usually about 0.8

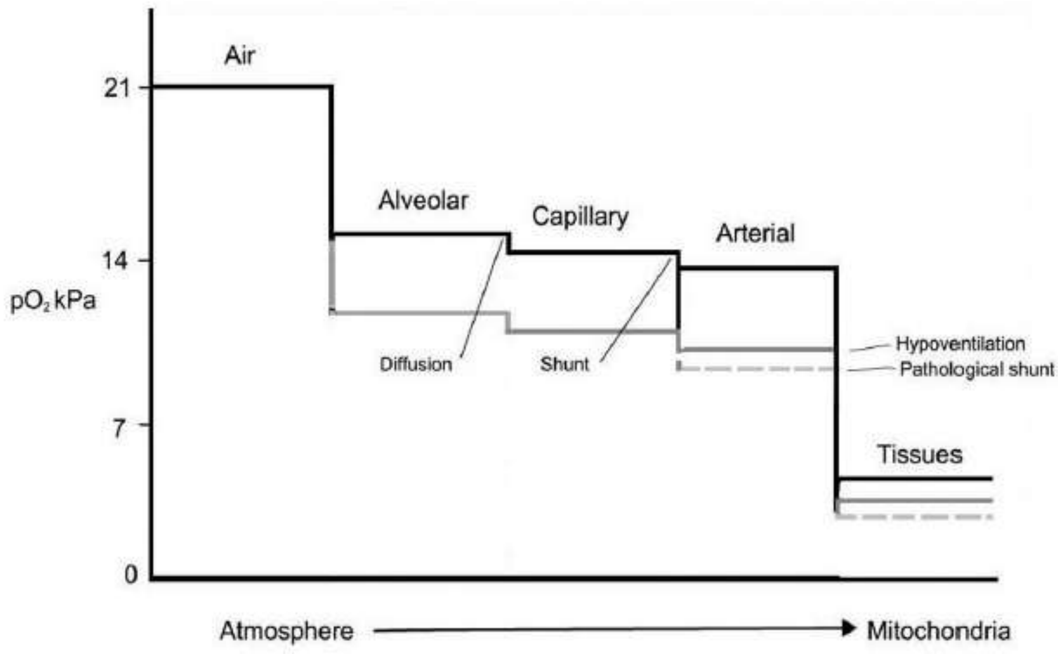

Figure 1: Oxygen transport in body

Oxygen in the air that we breathe is transported to each cell in the body. As per the law of diffusion, Oxygen diffuses from higher pressure gradient to lower pressure gradient. So when atmospheric oxygen reaches the cellular level, in mitochondria PO2 reaches the lowest level (1-1.5kPa). Mitochondria is the structures in cells responsible for energy production. This decrease in PO2 from air to the mitochondrion is known as the oxygen cascade. The successive steps down in PO2 occur for physiological reasons, but they can be influenced by pathological states, for instance hypoventilation, ventilation/perfusion inequality, or diffusion abnormality, that will result in tissue hypoxia.[21]

Oxygen is carried in blood and is supplied at cellular level through capillaries. Oxygen is carried combined with haemoglobin and small amount dissolved in the plasma.

When fully saturated one gram of haemoglobin can carry 1.34ml of oxygen. Therefore every litre of blood with a Hb concentration of 15g/dl-1 can carry about 200ml of oxygen when fully saturated with oxygen (i.e. exposed to a PO2 greater than 13kPa). At this PO2 only 3ml of oxygen will dissolve in each litre of plasma. If the PaO2 is increased significantly (by breathing 100% oxygen) then a small amount of extra oxygen will dissolve in the plasma (at a rate of 0.025ml O2/100ml of blood/kPa PO2) but there will normally be no significant increase in the amount carried by haemoglobin, as it is already >95% saturated with oxygen.[20]

OXYGEN DELIVERY

Adequate supply of the oxygen in the body is most important to avoid low oxygen saturation at the surgical wound site. Adequacy of oxygen delivery to the tissues depends on mainly three factors:

- Haemoglobin concentration.
- Cardiac output.
- Oxygenation.

The quantity of oxygen made available to the body in one minute is known as the oxygen delivery:[21]

Oxygen delivery (ml O2.min-1) = Cardiac output (l.min-1) x Hb concentration (g.l-1)

x 1.34 (ml O2.gHb-1) x % saturation

= 5000ml.min-1 x 200ml O2.1000ml blood-1

= 1000*ml O2.min-1

OXYGEN CONSUMPTION

Oxygen consumption in resting state by conscious person is approximately 250 ml, consuming about 25% of the arterial oxygen every minute. Venous blood haemoglobin is about 73% saturated (98% minus 25%). During resting phase oxygen consumption is less so usually oxygen delivery to cells exceeds. All the conditions which increases the oxygen consumption at cellular level is compensated by an increased cardiac output (as shown in the formula above). A low cardiac output, low haemoglobin concentration (anaemia) or low oxygen saturation will result in reduced tissue oxygen delivery, unless there is a compensatory change in one of the other factors. If body cannot supply sufficient oxygen by compensation than the tissues extract more oxygen from the haemoglobin and the saturation of mixed venous blood falls below 70%. Below a certain point, decreased oxygen delivery cannot be compensated and this results in anaerobic metabolism and lactic acidosis. This situation is known as supply-dependent oxygenation.[22]

OXYGEN STORES

Total amount of oxygen in the body depends on blood and the lungs. In blood it depends on total volume and haemoglobin concentration. In lungs it depends on fuctional residual capacity (FRC) and the alveolar concentration of oxygen. So the actual store of oxygen in the body is small, just to sustain life for few minutes. The FRC is the volume of air (about 3 litres in an adult) that is present in the lungs at the end of a normal expiration.

The major component of this store is the oxygen bound to haemoglobin, only a small part of these stores can be released without an unacceptable reduction in PaO2 (when haemoglobin is 50% saturated, the PaO2 will have fallen to 3.5kPa). Breathing 100% oxygen causes a large increase in the total oxygen stores as the FRC fills with oxygen. The major component of the store is now in the lung and 80% of this oxygen can be used without any reduction in haemoglobin saturation (PaO2 is still about 14kPa). This is the reason why pre-oxygenation is so effective.[22]

Principal stores of oxygen in the body	**Breathing AIR**	**Breathing 100% O2**
O_2 store in the lungs at FRC	450ml	3000ml
O_2 store bound to haemoglobin	850ml	950ml
O_2 dissolved or bound in tissues	250ml	300ml
Total	**1550ml**	**4250ml**

Table A. Oxygen store in body

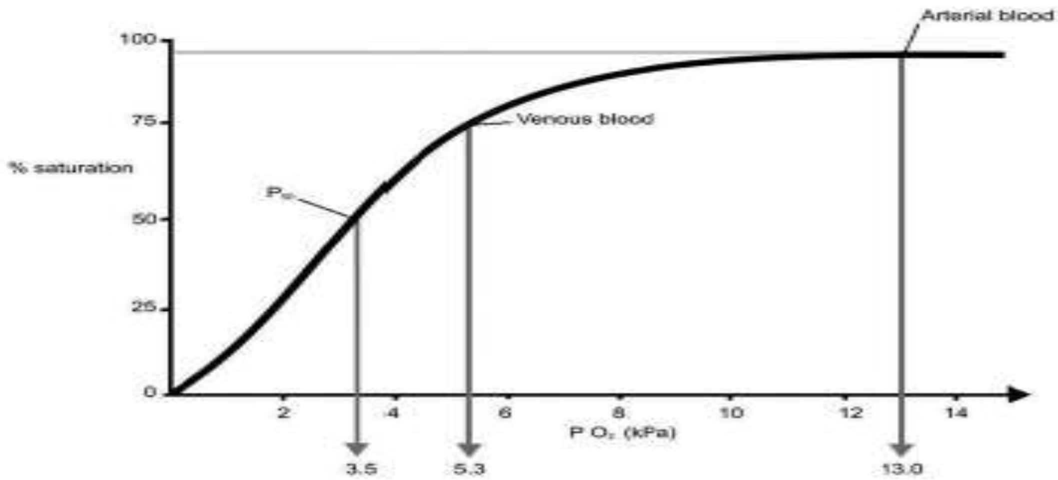

Figure 2. The oxygen-haemoglobin dissociation curve. The sigmoid curve arises because of ‘positive cooperativity’ of the 4 haemoglobin subunit – when the first subunit binds to oxygen a conformation (shape) change makes it more likely that the second and third subunits will bind to oxygen.

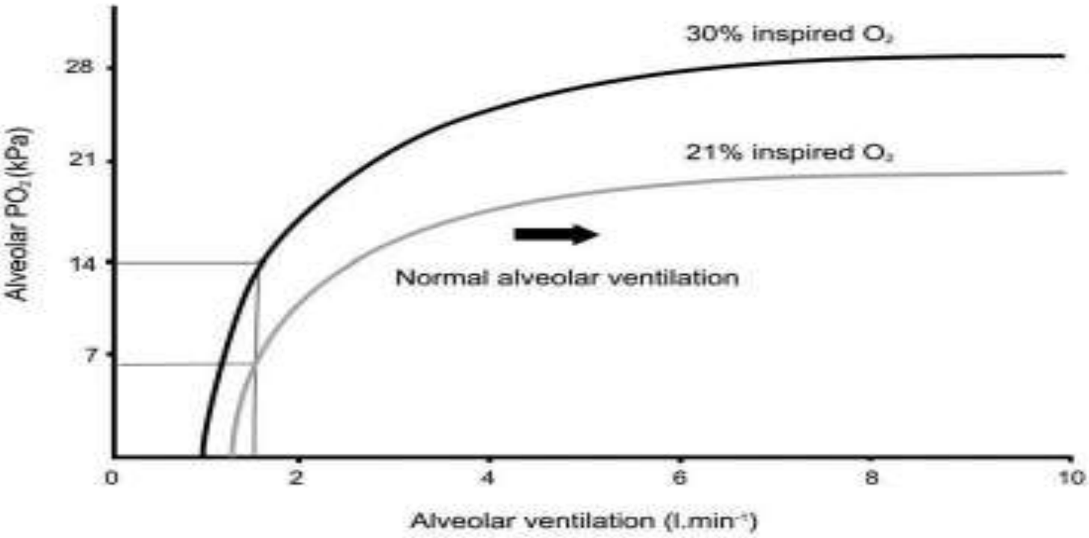

Figure 3. The effect on PaO2 of increasing the FiO2 from 21% (thin curve) to 30% (heavy curve) at a constant oxygen consumption of 200ml.min-1. The effect on PaO2 of increasing the FiO2 in a patient with an alveolar ventilation of 1.5l.min-1 is shown.

HYPEROXYGENATION

Hypoxic wounds not only have a slower rate of healing but also a higher risk of developing infections proportionate to the degree of tissue hypoxia.[23] Oxygen at the wound site is believed to be associated with heightened bactericidal activity of neutrophils through increased oxidative killing.[24,25] Additionally, the activity of antibiotics might be enhanced at higher levels of oxygen.[26]

Peripheral tissues are oxygenated via movement of oxygen down a partial pressure gradient. Oxygen is delivered via capillary flow, and anything that limits blood flow, decreases arterial oxygen content, or lessens movement of oxygen along its gradient can negatively impact tissue oxygenation.

Surgical wounds can be hypoxic due to 2 main factors:

1. Poor systemic oxygen delivery, which is determined by both the cardiac output and the arterial oxygen content, or by
2. Locally interrupted blood flow due to surgical trauma to blood vessels or edema (third spacing) causing increased intercapillary distance.

These 2 main factors are impacted by many others, including vasoconstriction—caused by hypothermia, hypovolemia, or pain, all of which are common during surgery—decreased cardiac function (eg, ischemia, failure), decreased oxygen content (eg, hypoxemia, significant anemia), and type and amount of fluid resuscitation during the perioperative period. Therefore, the rationale of hyperoxygenating a patient consists of increasing partial oxygen pressures at the wound site, increasing neutrophil activity with an ultimate decrease in SSIs.

OXYGEN DELIVERY SYSTEMS

A wide variety of cheap oxygen delivery systems are available. The mask and valve design and oxygen flow rate allows delivery of an inspired oxygen of 24-90% (Fio_2 0.26-0.90). The concentration of oxygen that patients inspire depends on the ventilatory minute volume (MV) and the flow rate of oxygen. The greater the ventilation, the lower the Fio_2 for a given flow rate of supplemental oxygen. It is impossible to provide a fixed Fio_2 to a patient with a varying ventilatory requirement unless the total ventilatory minute volume is provided at the required FiO_2.[21]

There are two basic types of oxygen mask which deliver either the entire (high flow mask) or a proportion (low flow mask) of the ventilatory requirement. High flow systems deliver about 40 l/min of gas through the mask, which is usually sufficient to meet the total respiratory demand. This ensures that the breathing pattern will not affect the FiO_2. The masks contain venturi valves, which use the principle of jet mixing (Bernoulli effect). When oxygen passes through a narrow orifice it produces a high velocity stream that draws a constant proportion of room air through the base of the venturi valve. Air entrainment depends on the velocity of the jet (the size of orifice and oxygen flow rate) and the size of the valve ports. It can be accurately controlled to give inspired oxygen levels of 24-60%.[22]

OXYGEN MASKS

Although many different designs of high and low flow systems are available, only a few are used regularly.

High flow, jet mixing masks are useful for accurately delivering low concentrations of oxygen (24-35%). They provide the total ventilatory requirement unaffected by the pattern of ventilation. In patients with chronic obstructive pulmonary disease and type II respiratory failure these masks reduce the risk of carbon dioxide retention while improving hypoxaemia. They are loose fitting and comfortable to wear. Rebreathing of expired gas is not a problem because the mask is flushed by the high flow rates.

Low flow masks—A concentration of up to 60% can be achieved with moderate oxygen flow rates (6-10 l/min), and these masks are used mainly in type I respiratory failure (for example, pulmonary oedema, pulmonary embolus). At low oxygen flow rates (<5 l/min) significant rebreathing may occur because exhaled air is not adequately flushed from the face mask. This makes it difficult to achieve a low inspired oxygen concentration and prevent retention of carbon dioxide. These masks are generally not suitable for patients with type II respiratory failure.

Non Rebreathing/Reservoir and anaesthetic type oxygen masks—Partial rebreathing masks incorporating non-rebreathing valves and reservoir bags are not in common use but can provide concentrations greater than 60% at low oxygen flow rates. In cardiac or respiratory arrest, tight fitting anaesthetic type masks can achieve 100% oxygen, but prolonged use risks oxygen toxicity and reabsorption atelectasis.[26] In our study we used this Non Rebreathing/ Reservoir mask to deliver oxygen during perioperative period and in post operative ward for 2 hours with 10lit/min oxygen and with this FiO2 was achieved around 80% with 10lit/min oxygen flow.

Figure 4: Non rebreathing/Reservoir Mask

Nasal prongs are simple and convenient to use. The Fio_2 depends on the flow rate of oxygen (1-6 l/min) and varies according to ventilatory minute volume. At an oxygen flow rate of 2 l/min the oxygen concentration in the hypopharynx of a resting subject is 25-30%. Nasal prongs prevent rebreathing, are comfortable for long periods, and allow oxygen to be continued during talking and eating. Local irritation and dermatitis may occur with high flow rates.

Non-invasive assisted ventilation—Supplemental oxygen may be provided through tight fitting nasal or full face masks during nasal intermittent positive pressure ventilation and continuous positive airways pressure. These techniques have been used to support ventilation in sleep associated hypoventilation, during weaning from mechanical ventilation, and in respiratory failure associated with chronic obstructive pulmonary disease.[26]

OTHER DELIVERY SYSTEMS

Hyperbaric oxygenation—At a pressure of 300 kPa the small quantity of oxygen in solution in the blood can be increased by up to 300% and diffusion through tissues may be improved. Advice is best sought on an individual basis from the specialist centres providing this service.

Humidification of oxygen—When oxygen is delivered at a flow rate of 1-4 l/min by mask or nasal prongs, the oropharynx or nasopharynx provides adequate humidification. At higher flow rates or when oxygen is delivered directly to the trachea humidification is necessary.[25]

APPENDICITIS

ANATOMY

The appendix is the commencement of the large gut. At an early embryonic stage it has the same caliber as the caecum and is in line with it. It is formed by the excessive growth of the right wall of the caecum which pushes the appendix to the inner side. It varies in length from 2.5 to 23 cm. The average length is 9 cm. Congenital absence of appendix is extremely rare- 0.0009% (Collins, D.C., Am. J. Surg., 1951, 82,689). It has the same coat as the large gut, but the muscular coat may be deficient in some parts so that the peritoneum and mucous membrane is separated by connective tissue through which infection may readily spread from mucous membrane to peritonem. Its wall contains much lymphoid tissue. The base of the appendix is located at the convergence of the taeniae along the inferior aspect of the caecum and this anatomic relationship facilitates identification of the appendix at operation. The tip of the appendix may lie in various locations. The most common location is retrocaecal but within the peritoneal cavity. It is pelvic in 30% and retroperitoneal in 7% of the population.[27] The varying location of the tip of the appendix likely explains the myriad of symptoms that are attributable to the inflamed appendix.

The appendiceal artery, a branch of the ileocolic artery, supplies the appendix which runs in the mesoappendix. In incomplete mesoappendix artery lies on the wall of appendix in its distal parts and the wall of vessel may be eroded in suppurative appendicitis.

Histologic examination of the appendix indicates that goblet cells, which produce mucus, are scattered throughout the mucosa. The submucosa contains lymphoid follicles, leading to speculation that the appendix might have an important, as yet undefined, immune function early in development. The lymphatics drain into the anterior ileocolic lymph nodes. In adults, the appendix has no known function.

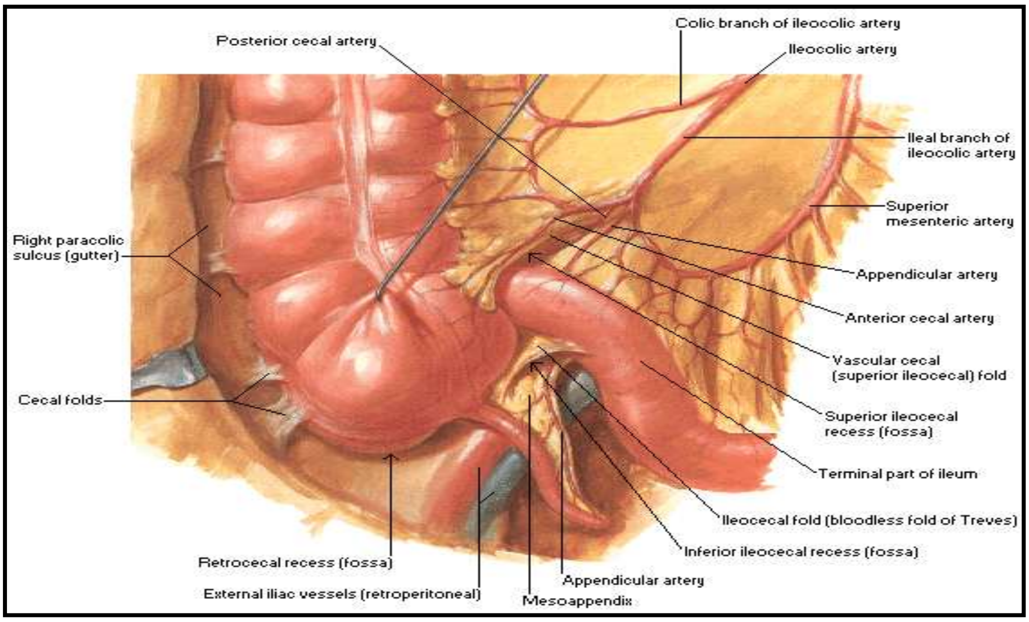

FIGURE 5: ANATOMY OF ILEOCAECAL REGION

HISTORICAL PERSPECTIVE

The term appendicitis was coined by Reginald Fitz (Boston) in 1886 and recommended early surgical treatment of the disease. The first survival of a patient after appendicectomy was noted by Richard Hall, which focused attention on the surgical treatment of acute appendicitis. But the master surgeon Chester McBurney is credited for notable work on acute appendicitis. In 1889 he described characteristic migratory pain from umbilicus to right iliac fossa. McBurney described a right lower quadrant muscle-splitting incision for removal of the appendix in 1894. The mortality rate was very high before the era of antibiotics, but remarkable improvement was noted after 1940 when broad spectrum antibiotic was introduced. Imaging modalities like ultrasonography and CT scan have improved the preoperative accuracy of diagnosis. First laparoscopic appendicectomy was done by Prof. Kurt Semm in 1982.

Laparoscopy has the advantage of minimal access and helpful in excluding other causes of abdominal pain. Laparoscopic approach gained widespread acceptance during the past decade. Other to appendicectomy have been reported Single-incision laparoscopic surgery (SILS) and transvaginal are other minimally invasive approaches, however these have not as yet been widely adopted.[28,29]

BACTERIOLOGY

The flora in the normal Appendix is the part of large gut and has bacterial flora similar to that in the colon, with various facultative aerobic and anaerobic bacteria. Escherichia coli, Streptococcus viridans, Bacteroides and Pseudomonas are frequently isolated bacteria in acute and perforated appendicitis.[30]

TYPE OF BACTERIA	PATIENTS (%)
Anaerobic	
Bacteroides fragilis	80
Bacteroides thetaiotaomicron	61
Bilophila wadsworthia	55
Peptostreptococcus spp.	46
Aerobic	
Escherichia coli	77
Streptococcus viridans	43
Group D streptococcus	27
Pseudomonas aeruginosa	18

TABLE B: BACTERIA COMMONLY ISOLATED IN PERFORATED APPENDICITIS

Adapted from Bennion RS, Thompson JE: Appendicitis. In Fry DE (ed): Surgical infections, Boston, 1995, Little, Brown, pp 241-250.

PATHOPHYSIOLOGY

Obstruction of the lumen is believed to be the major cause of acute appendicitis.[27] This may be caused by inspissated stool (fecolith or appendicolith), lymphoid hyperplasia, vegetable matter or seeds, parasites, or a neoplasm. The lumen of the appendix is small in relation to its length and this configuration may predispose to closed-loop obstruction. Obstruction of the appendiceal lumen contributes to bacterial overgrowth and continued secretion of mucus leads to intraluminal distention and increased wall pressure. Luminal distention produces the visceral pain sensation experienced by the patient as periumbilical pain.[28] Subsequent impairment of lymphatic and venous drainage leads to mucosal ischemia. These findings in combination promote a localized inflammatory process that may progress to gangrene and perforation. Inflammation of the adjacent peritoneum gives rise to localized pain in the right lower quadrant. Although there is considerable variability, perforation typically occurs after at least 48 hours from the onset of symptoms and is accompanied by an abscess cavity walled off by the small intestine and omentum. Rarely, free perforation of the appendix into the peritoneal cavity occurs, which may be accompanied by peritonitis and septic shock.[29,30]

DIAGNOSIS

The differential diagnosis of appendicitis can include almost all causes of abdominal pain, as described in the classic treatise, *Cope's Early Diagnosis of the Acute Abdomen.*[31] A useful rule is never to place appendicitis lower than second in the differential diagnosis of acute abdominal pain in a previously healthy person.

HISTORY

Early diagnosis remains the most important clinical goal in patients with suspected appendicitis and can be made primarily on the basis of the history and physical examination in most cases. The typical presentation begins with periumbilical pain, caused by the activation of visceral afferent neurons, followed by anorexia and nausea. The pain then localizes to the right lower quadrant as the inflammatory process progresses to involve the parietal peritoneum overlying the appendix. This classic pattern of migratory pain is the most reliable symptom of acute appendicitis.[32] A bout of vomiting may occur, in contrast to the repeated bouts of vomiting that typically accompany viral gastroenteritis or small bowel obstruction. Fever ensues, followed by the development of leukocytosis. These clinical features may vary. Occasional patients have urinary symptoms or microscopic hematuria, perhaps because of inflammation of periappendiceal tissues adjacent to the ureter or bladder, and this may be misleading. Although most patients with appendicitis develop an adynamic ileus and absent bowel movements on the day of presentation, occasional patients may have diarrhea. Others may present with small bowel obstruction related to contiguous regional inflammation. Therefore, appendicitis needs to be considered as a possible cause of small bowel obstruction, especially in patients without prior abdominal surgery.

PHYSICAL EXAMINATION

Patients with acute appendicitis typically look ill and are lying still in bed. Low-grade fever is common (≈38° C). Examination of the abdomen usually reveals diminished bowel sounds and focal tenderness, with voluntary guarding. The exact location of the tenderness is directly over the appendix. Usually, this occurs at McBurney’s point, located one third of the distance along a line drawn from the anterior superior iliac spine to the umbilicus; however, the normal appendix is mobile, so it may become inflamed at any point on a 360-degree circle around the base of the cecum. Thus, the site of maximal pain and tenderness can vary. Peritoneal irritation can be elicited on physical examination by the findings of voluntary and involuntary guarding, percussion, or rebound tenderness. Any movement, including coughing (Dunphy's sign), may cause increased pain. Other findings may include pain in the right lower quadrant during palpation of the left lower quadrant (Rovsing's sign), pain on internal rotation of the hip (obturator sign, suggesting a pelvic appendix), and pain on extension of the right hip (iliopsoas sign, typical of a retrocecal appendix).

Rectal and pelvic examinations are most likely to be negative. However, if the appendix is located within the pelvis, tenderness on abdominal examination may be minimal, whereas anterior tenderness may be elicited during rectal examination as the pelvic peritoneum is manipulated. Pelvic examination with cervical motion may also produce pain in this setting.

If the appendix perforates, abdominal pain becomes intense and more diffuse and abdominal muscular spasm increases, producing rigidity. The heart rate rises, with an elevation of temperature above 39° C. The patient may appear ill and require a brief period of fluid resuscitation and antibiotics before the induction of anesthesia.

LABORATORY STUDIES

The white blood cell count is elevated, with more than 75% neutrophils in most patients. A completely normal leukocyte count and differential is found in approximately 10% of patients with acute appendicitis. A high white blood cell count (>20,000/mL) suggests complicated appendicitis with gangrene or perforation. A urinalysis can also be helpful in excluding pyelonephritis or nephrolithiasis. Minimal pyuria, frequently seen in older women, does not exclude appendicitis from the differential diagnosis because the ureter may be irritated adjacent to the inflamed appendix. Although microscopic hematuria is common in appendicitis, gross hematuria is uncommon and may indicate the presence of a kidney stone. Other blood tests are generally not helpful and are not indicated for the typical patient with suspected appendicitis.

RADIOGRAPHIC STUDIES

The gold standard for the diagnosis of appendicitis still remains pathologic confirmation after appendicectomy. Among patients with abdominal pain, ultrasonography has a sensitivity of approximately 85% and a specificity of more than 90% for the diagnosis of acute appendicitis. Sonographic findings consistent with acute appendicitis include an appendix of 7 mm or more in anteroposterior diameter, a thick-walled, noncompressible luminal structure seen in cross section, referred to as a *target lesion*, or the presence of an appendicolith (Figure 3). In more advanced cases, periappendiceal fluid or a mass may be found. Ultrasonography has the advantages of being a noninvasive modality requiring no patient preparation that also avoids exposure to ionizing radiation. Thus, it is commonly used in children and in pregnant patients with equivocal clinical findings suggestive of acute appendicitis. Variation in results are due to operator skill, increased bowel gas content, obesity, anatomic variants, and limitations to explore patients with previous laparotomies.

Computed tomography (CT) is commonly used in the evaluation of adult patients with suspected acute appendicitis. Improved imaging techniques, including the use of 5-mm sections, have resulted in increased accuracy of CT scanning, which has a sensitivity of approximately 90% and a specificity of 80% to 90% for the diagnosis of acute appendicitis in patients with abdominal pain.[33] Results of a recent randomized study have suggested that the use of high-resolution multidetector CT (64-MDCT) with or without oral or rectal contrast results in more than 95% accuracy in the diagnosis of acute appendicitis.[34]

Appropriateness criteria have been published by the American College of Radiology (ACR) for right lower quadrant pain suggestive of appendicitis. In the appropriateness criteria, ratings of 7 to 9 are considered "usually appropriate." Computed tomography of the abdomen and pelvis with intravenous contrast is rated 8, and CT of the abdomen and pelvis without contrast is rated 7.[33]

Ratings of 4 to 6 indicate that studies "may be appropriate." Right lower quadrant ultrasound with graded compression is rated 6, and abdominal radiographs (for excluding free air or obstruction) are rated 5. Magnetic resonance imaging is rated 4. Ratings of 1 to 3 indicate that studies "are usually not appropriate." Barium enema and technetium-99m white cell scanning are rated 3.[34]

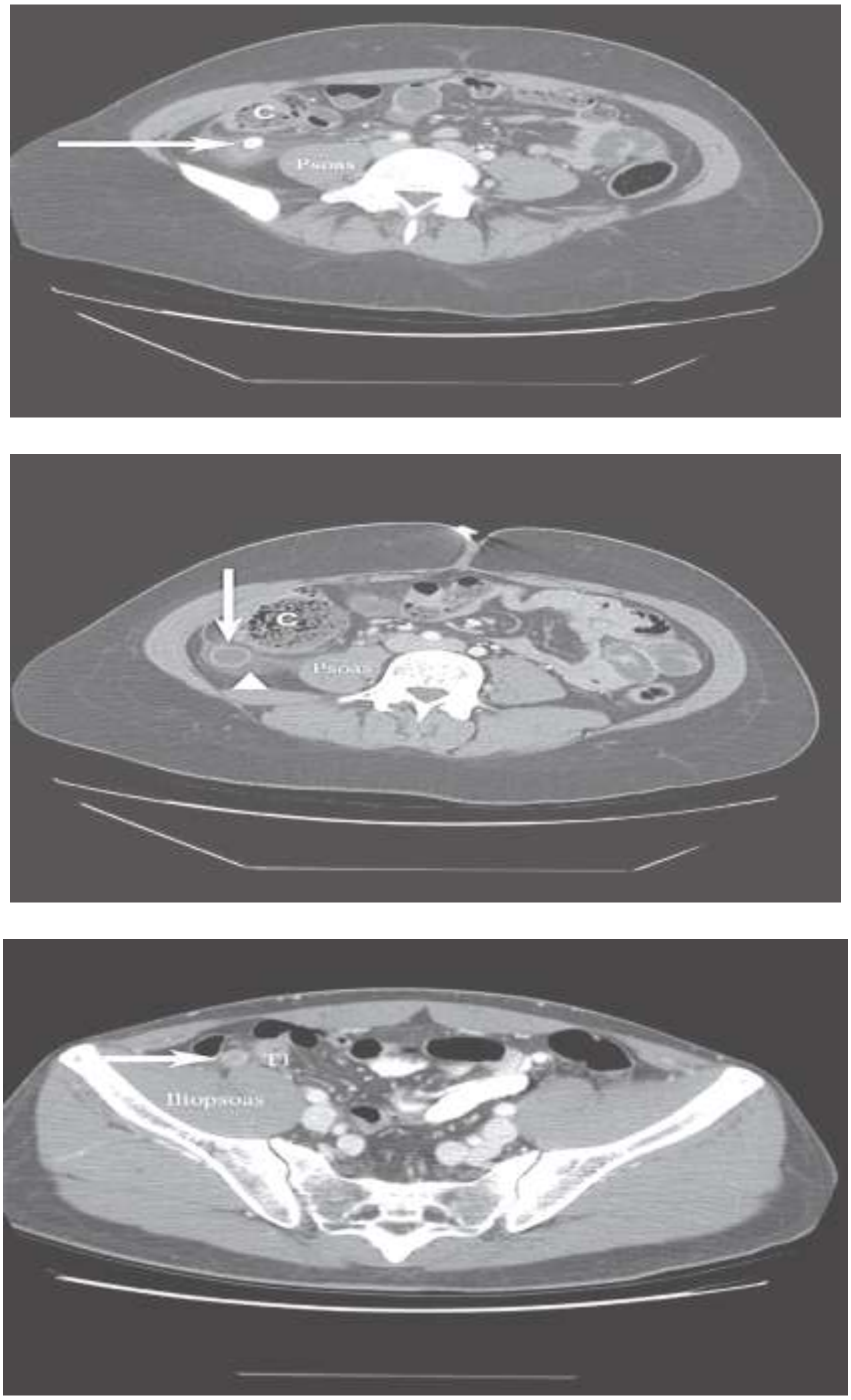

FIGURE 6: CT IMAGES OF ACUTE APPENDICITIS

A, CT scan of the abdomen or pelvis in a patient with acute appendicitis may reveal an appendicolith *(arrow).* B, CT typically shows a distended appendix (*arrow*) with diffuse wall thickening and periappendiceal fluid *(arrowhead).* C, The appendix may be described as having mural stratification, referring to the layers of enhancement and edema within the wall *(arrow);* this may also be referred to as a target sign. *C,* Cecum; *TI,* terminal ileum.

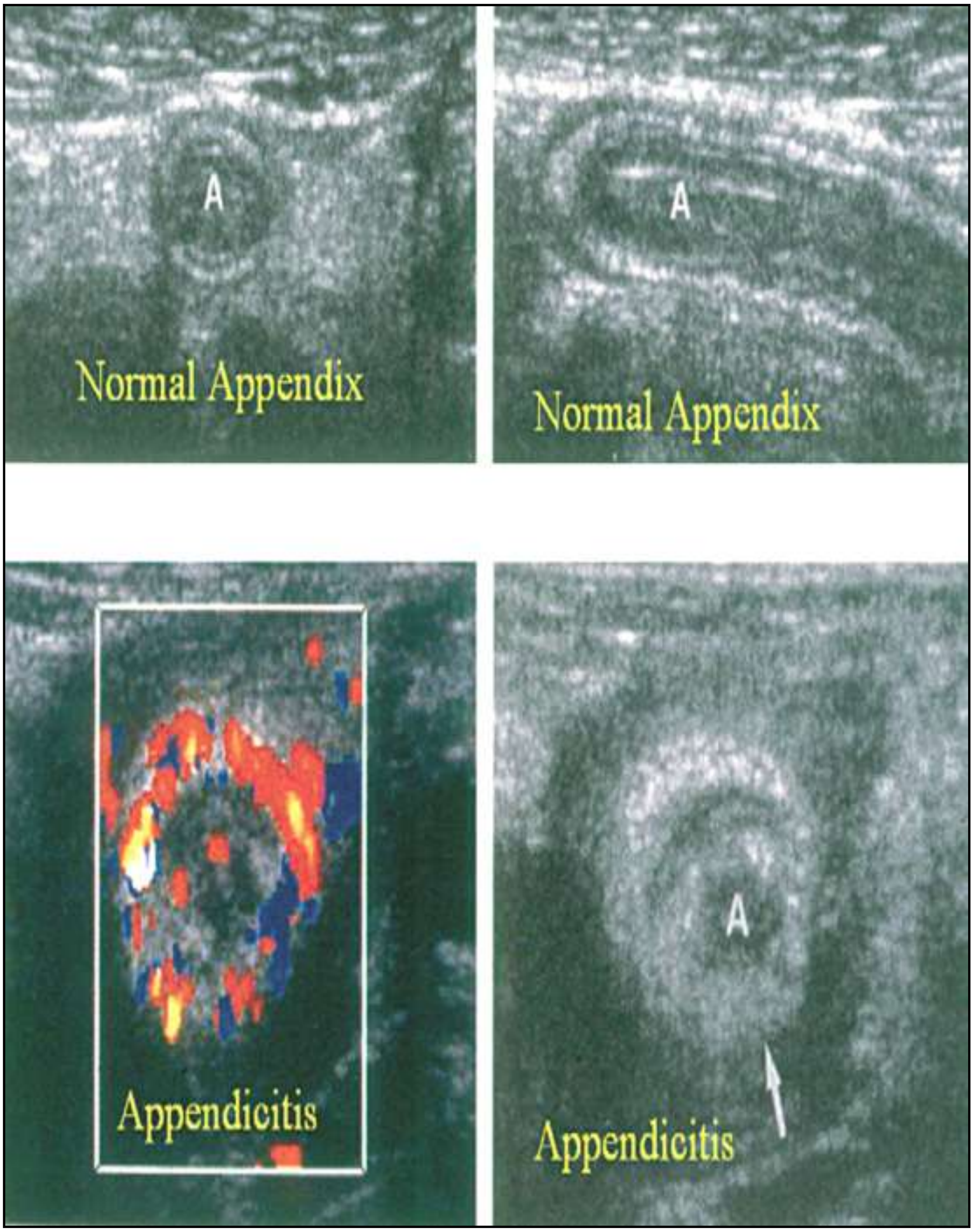

FIGURE 7: ULTRASOUND IMAGES OF ACUTE APPENDICITIS

Ultrasound of a normal appendix *(top)* illustrating the thin wall in coronal *(left)* and longitudinal *(right)* planes. In appendicitis, there is distention and wall thickening *(bottom, right)*, and blood flow is increased, leading to the so-called *ring of fire appearance*. *A*, Appendix.

TREATMENT

Most patients with acute appendicitis are managed by prompt surgical removal of the appendix. A brief period of resuscitation is usually sufficient to ensure the safe induction of general anesthesia. Preoperative antibiotics cover aerobic and anaerobic colonic flora.

Several prospective randomized studies have compared laparoscopic and open appendicectomy, and the overall differences in outcomes remain small. The percentage of appendectomies performed laparoscopically continues to increase.[48] Obese patients have less pain and shorter hospital stays after laparoscopic versus open appendicectomy.[49] Patients with perforated appendicitis have lower rates of wound infections following laparoscopic removal of the appendix.[50] Patients treated laparo-scopically have improved quality of life scores 2 weeks after surgery.[51] and lower readmission rates. As compared with open appendicectomy, the laparoscopic approach involves higher operating room costs, but these have been counterbalanced in some series by shorter lengths of stay. For patients in whom the diagnosis remains uncertain after the preoperative evaluation, diagnostic laparoscopy is useful because it allows the surgeon to examine the remainder of the abdomen, including the pelvis, for abnormalities. Our practice is to perform appendectomies laparoscopically for most patients, particularly fertile women, obese patients, and cases of diagnostic uncertainty. Extensive prior lower abdominal surgery with resultant adhesions pre-cludes safe laparoscopic port placement in rare patients. Open appendicectomy is usually easily performed through a transverse right lower quadrant incision (Davis-Rockey) or an oblique incision (McArthur-McBurney; Figure 8). In patients with a large phlegmon or diagnostic uncertainty, a subumbilical midline incision may be used. For uncomplicated cases, we prefer a transverse, muscle-splitting incision lateral to the rectus abdominis muscle over McBurney's point. Local anesthetic, administered before the incision, reduces postoperative pain.[52]

After the peritoneum is entered, the inflamed appendix is identified by its firm consistency and delivered into the field. Particular attention is paid to gentle handling of the inflamed tissues to minimize the risk for rupture during the procedure. In difficult cases, enlarging the incision and working down the trajectory of the taeniae on the cecum will often facilitate localization and delivery of the appendix. The mesoappendix is divided between clamps and ties (see Figure 8*A*). The base of the appendix is skeletonized at its junction with the cecum. A heavy absorbable tie is placed around the base of the appendix and the specimen is clamped and divided (see Figure 8*B*). An absorbable purse-string suture or Z stitch is placed into the cecal wall (see Figure 8*C*) and the appendiceal stump is inverted into a fold in the wall of the cecum (see Figure 8*D*). Simple ligation and inversion probably have equivalent outcomes. If the base of the appendix and adjacent cecum are extensively indurated, an ileocecal resection is performed. The wound is closed primarily in most cases because the wound infection rate is less than 5%.

Laparoscopic appendicectomy offers the advantage of diagnostic laparoscopy combined with the potential for shorter recovery and incisions that are less conspicuous. If a CT scan was obtained preoperatively, it needs to be reviewed by the surgeon for useful information regarding the position of the appendix relative to the cecum. After injection of local anesthetic, we place a 10-mm port into the umbilicus, followed by a 5-mm port in the suprapubic midline region and a 5-mm port midway between the first two ports and to the left of the rectus abdominis muscle (Figure 9). The 5-mm, 30-degree laparoscope is moved to the central port, with the surgeon and assistant both on the patient's left. With the patient in the Trendelenburg position and rotated left side down, we gently sweep the terminal ileum medially and follow the taeniae of the cecum caudal to locate the appendix, which is then elevated. The mesoappendix is divided using a 5-mm harmonic scalpel or Liga-Sure, or between clips, depending on the thickness of this tissue (see Figure 9*A*). We typically encircle the appendix with one or two heavy absorbable Endoloops cinched down at the base of the appendix, then place a third Endoloop on the specimen side (≈1 cm distally), and divide the appendix (see Figure 9*B* and 9*C*). In patients in whom the base is indurated and friable, we use a 30-mm endoscopic stapler to divide the appendix. For most patients, however, considerable added cost of the stapler is unwarranted. Any spillage of fluid is promptly aspirated and, similarly, any identified appendicoliths are removed to prevent postoperative abscess formation. The appendix is placed into a specimen bag and removed with the port through the umbilical wound (see Figure 9*D*). Fascia at the 10-mm trocar site is closed, and all wounds are closed primarily.

Patients are offered an unrestricted diet and oral pain medication after surgery. Patients with nonperforated appendicitis are discharged within 24 hours of procedure.

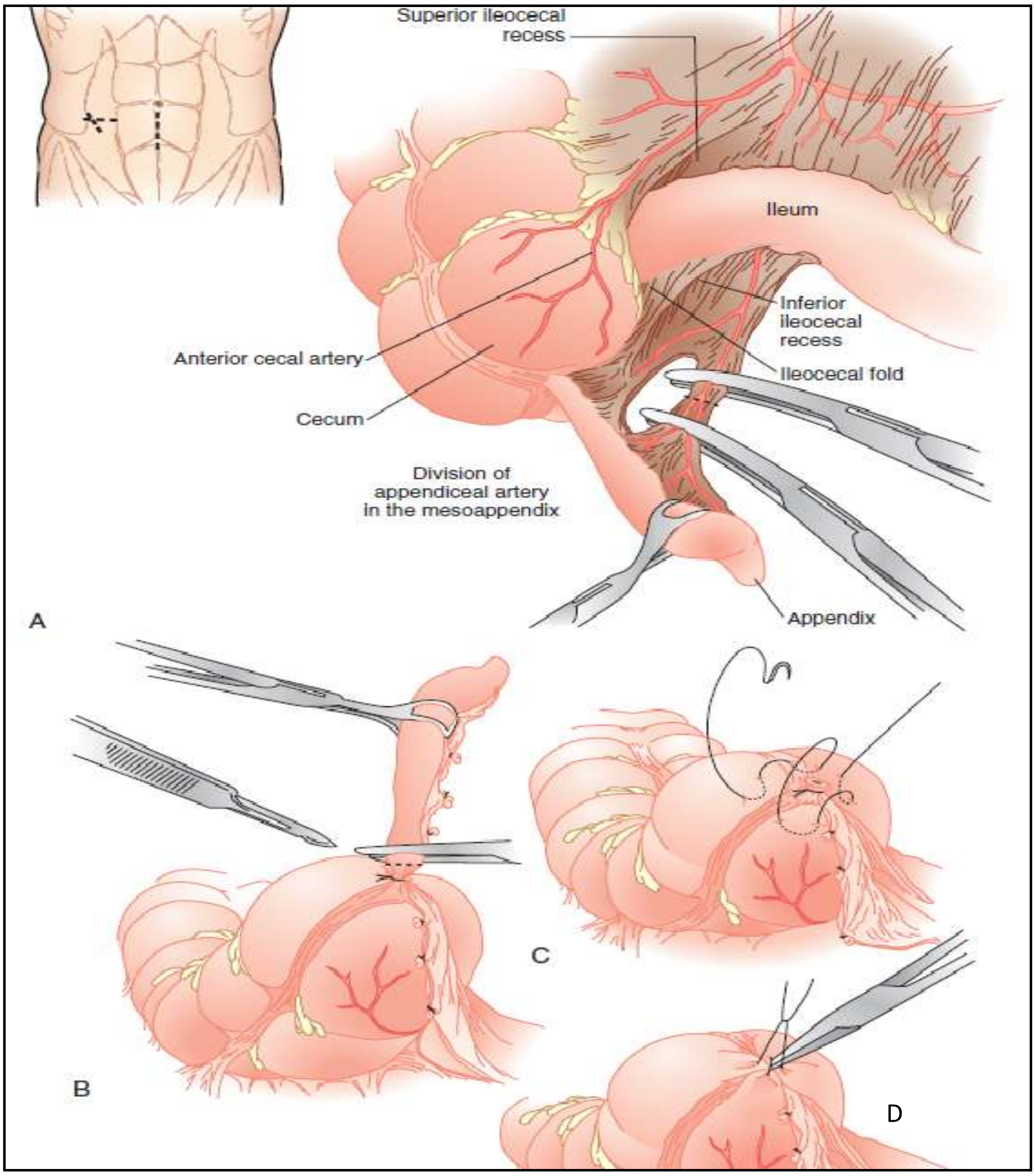

FIGURE 8: OPEN APPENDICECTOMY

A, *Left,* Location of possible incisions for an open appendicectomy. *Right,* Division of the mesoappendix. B, Ligation of the base and division of the appendix. C, Placement of purse-string suture or Z stitch. D, Inversion of the appendiceal stump. (From Ortega JM, Ricardo AE: Surgery of the appendix and colon. In Moody FG [ed]: Atlas of ambulatory surgery, Philadelphia, 1999, WB Saunders.)

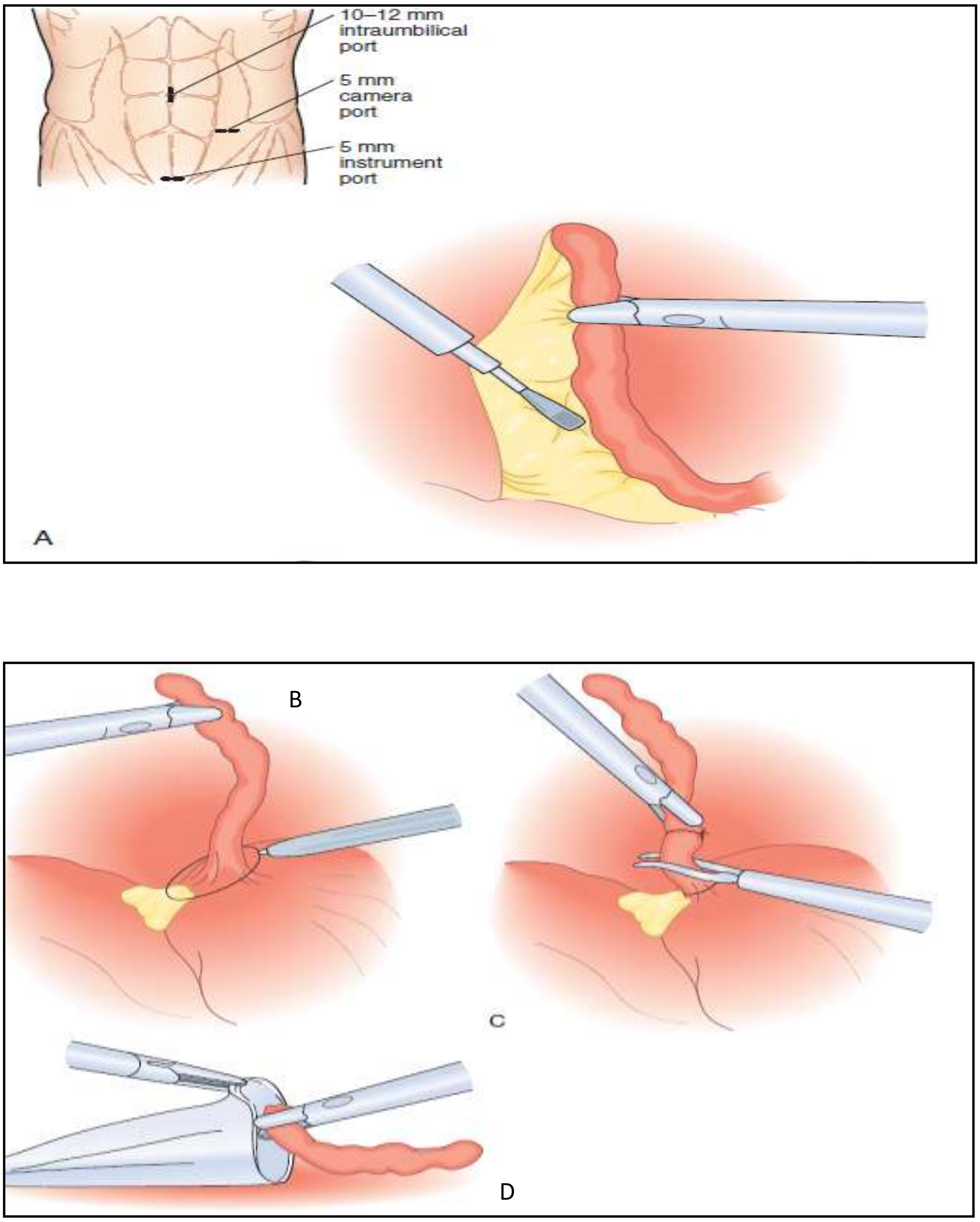

FIGURE 9: LAPAROSCOPIC APPENDICECTOMY

A, *Upper left,* Location of port sites for laparoscopic appendicectomy. *Right,* Division of the mesoappendix using the harmonic scalpel. B, Placement of an absorbable Endoloop encircling the base of the appendix. C, Division of the appendix between Endoloops. D, Placement of the appendix into a specimen bag before removal of the appendix with the umbilical port.

SURGICAL SITE INFECTION IN APPENDICECTOMY

Surgical site infections and deep space infections or abscesses are the most common complications seen after appendicectomy. Approximately 5% of patients with uncomplicated appendicitis develop wound infections after open appendicectomy. Laparoscopic appendicectomy is associated with a lower incidence of wound infections; this difference is magnified in groups of patients with perforated appendicitis (14% versus 26%).

SURGICAL SITE INFECTION

Infections that occur in the wound created by an invasive surgical procedure are generally referred to as surgical site infections (SSIs). SSIs are one of the most important causes of healthcare-associated infections (HCAIs). A prevalence survey undertaken in 2006 suggested that approximately 8% of patients in hospital in the UK have an HCAI. SSIs accounted for 14% of these infections and nearly 5% of patients who had undergone a surgical procedure were found to have developed an SSI. However, prevalence studies tend to underestimate SSI because many of these infections occur after the patient has been discharged from hospital.

SSIs are associated with considerable morbidity and it has been reported that over one-third of postoperative deaths are related, at least in part, to SSI. However, it is important to recognize that SSIs can range from a relatively trivial wound discharge with no other complications to a life-threatening condition. Other clinical outcomes of SSIs include poor scars that are cosmetically unacceptable, such as those that are spreading, hypertrophic or keloid, persistent pain and itching, restriction of movement, particularly when over joints, and a significant impact on emotional wellbeing.

SSI can double the length of time a patient stays in hospital and thereby increase the costs of health care. The main additional costs are related to re-operation, extra nursing care and interventions, and drug treatment costs. The indirect costs, due to loss of productivity, patient dissatisfaction and litigation, and reduced quality of life, have been studied less extensively.[53]

In the context of Indian health system, where average postoperative environment and care is presumably not up to the mark, the risk of postoperative infection is high. Surgical site infection may be prevented by controlling the risk factors before the surgery.

SURGICAL SITE INFECTION

A post operative wound infection or surgical site infection (SSI) is an infection of a wound from a surgery. Many micro-organisms live in and on our bodies and also in our environment. The bacteria may come from the skin; from the air, soil or water; or from the object used during the surgery (Plowman, 2000). Likewise, it may be caused by complications from surgical hypothermia; contamination of the incision area by skin flora; surgical instrument contamination; and bacterial cross–contamination. Our bodies have natural defenses against the few germs that can cause harm. Our skin, for example, prevents germs from entering our bodies. A surgical wound infection occurs when germs enter the incision that the surgeon makes through patient's skin in order to carry out the operation. Most surgical wound infections are limited to the skin, but can spread occasionally to deeper tissues. Infections are more likely to occur after surgery on parts of the body that harbor lots of germs. It may affect closed wounds or wounds left open to heal; superficial or deep tissues; and in severe cases, the internal organs. A surgical wound infection can develop at any time from two to three days after surgery until the wound has healed (usually two to three weeks after the operation). Very occasionally, an infection can occur several months after an operation. An early infection presents within 30 days of a surgical procedure, whereas an infection is described as intermediate if it occurs between one and three months afterwards and late if it presents more than three months after surgery. A wound infection is described as minor if there is discharge without cellulitis or deep tissue destruction, and major if the discharge of pus is associated with tissue breakdown.[53]

CDC (Centers for Disease Control and Prevention) (Horan *et al.*, 1992) provides guidelines and tools to the healthcare community to stop surgical site infections and resources to help the public understanding these infections and take measures to safeguard their own health when possible (CDC, 2012).[54,55]

SIGN AND SYMPTOMS OF SSI

Postoperative infection often presents with nonspecific pain and swelling and can be difficult to diagnose accurately. Timely detection and accurate localization of infectious processes have important clinical implications and are critical to appropriate patient management.

Specific sign and symptoms of surgical site infection could be the following

- A wound that is painful, even though it does not look like it should be.
- High or low body temperature, low blood pressure, or a fast heart beat.
- Increased discharge (blood or other fluid) or pus coming out of the wound. The discharge or pus may have an odd color or a bad smell.

- Increased swelling that goes past the wound area and does not go away after five days. Swollen areas usually look red, feel painful, and feel warm when you touch them.
- Wounds that do not heal or get better with treatment.

TYPE OF SSI

According to the Centers for Disease Control and Prevention (CDC)'s guideline, SSIs are separated into three types, depending on the depth of infection penetration into the wound (Mangram *et al.*, 1999). By these criteria, SSIs are classified as being either incisional or organ/space.[55,56]

An SSI typically occurs within 30 days after surgery. The CDC describes 3 types of surgical site infections:

- Superficial incisional SSI. This infection occurs just in the area of the skin where the incision was made.
- Deep incisional SSI. This infection occurs beneath the incision area in muscle and the tissues surrounding the muscles.
- Organ or space SSI. This type of infection can be in any area of the body other than skin, muscle, and surrounding tissue that was involved in the surgery. This includes a body organ or a space between organs.[56,57]

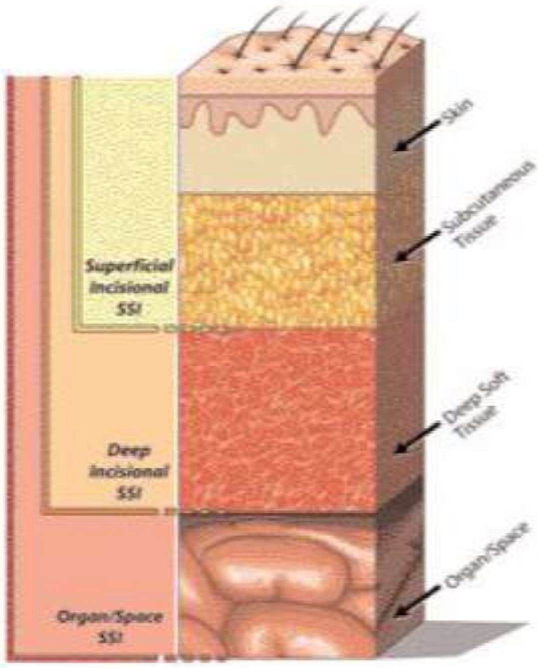

Figure 10: Types of SSI (Pear,2007)

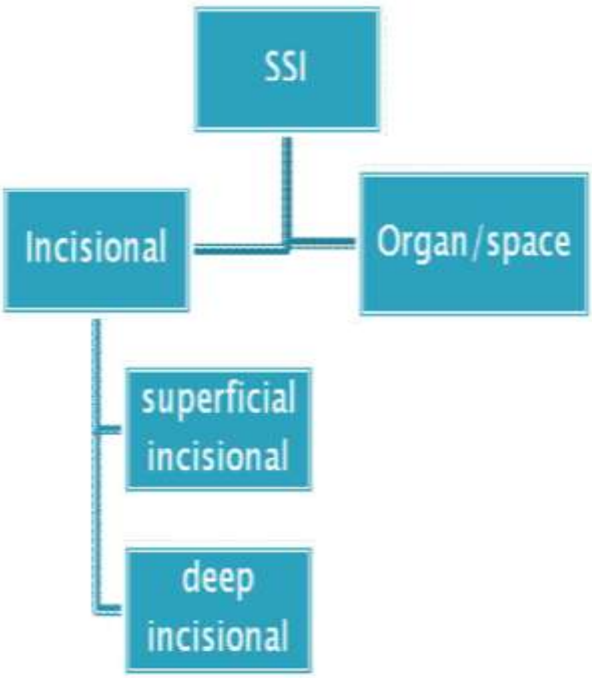

Chart A: Classification of SSI

RATES OF INFECTION

In various studies, the rate of infection has been found out base on different influencing factors. These factors include, Type of surgery, surgical classification, Area of surgery, Patient's ASA physical status, length of operation, prophylaxis use of antibiotic and also some patient related risk factors like- age, Diabetes Mellitus, Obesity, Smoking, Pre-existing Remote Body Site Infection etc. According to the NNIS (National Nosocomial Infections Surveillance by US Centres for Disease Control) system reports, SSIs are the third most commonly reported nosocomial infection, accounting for 14% to 16% of all nosocomial infections among hospitalized patients.[58]

In India the incidence of Surgical Site Infections (SSls) ranged from 11% to 30% [59] and accounts for 38% among various types of nosocomial infections.[60]

Before the systematic use of prophylactic antibiotics infection rates were 1-2% or less for clean wounds, 6-9% for clean-contaminated wounds, 13-20% for contaminated wounds and about 40% for dirty wounds.[53] But now infection rates in US National Nosocomial Infection Surveillance (NNIS) system hospitals were reported to be: clean 2.1%, clean-contaminated 3.3%, contaminated 6.4% and dirty 7.1%.[61] So since the introduction of routine prophylactic antibiotic use, infection rates in the most contaminated groups have reduced drastically. There is, however, considerable variation in each class according to the type of surgery being performed. A research was carried out over a two year period in Cumhuriyet University Medicine Faculty Hospital in Sivas, Turkey. Where, High infection rates were noted after colon resection (32·1%), gastric and oesophageal operations (21·1%), cholesystectomy (17·2%), and splenectomy (10·2%) and Low infection rates were noted after thyroidectomy, mastectomy, caesarean section and abdominal hysterectomy.[62]

SOURCES OF INFECTION

Sources of infection are widely varied. Infections may be primarily acquired from a community or endogenous source such as that following a perforated peptic ulcer or secondarily from exogenous sources such as from the operating theatre with inadequate air filtration or the ward (e.g. poor hand washing compliance) or from contamination at or after surgery (such as an anastomotic leak). Wound infection is caused by exogenous or endogenous bacteria; infection is influenced not only by the source of the infecting inoculum but also by the bacterial characteristics.[63]

ENDOGENOUS FACTORS OR SOURCES OF BACTERIA:

- Co-existing infection in other site of body
- Skin
- Bowel
- Nature and site of operation (Clean, Clean-contaminated, contaminated and Dirty)

EXOGENOUS FACTORS OR SOURCES OF BACTERIA

- Operating team–related – Comportment; Use of impermeable drapes and gowns; Surgical scrub.
- Operating room–related - Traffic control; Cleaning; Air

Surgical wound infections are also strongly influenced by the risk factors related to patients - extremities of age, obesity, diabetes mellitus, smoking habit, coexisting infection at other site etc.

ETIOLOGICAL AGENTS:

Many different bacteria, viruses, fungi and parasites may cause wound infections. Infections may be caused by a microorganism acquired from another person in the hospital (cross-infection) or may be caused by the patient's own flora (endogenous infection). Some organisms may be acquired from an inanimate object or substances recently contaminated from another human source (environmental infection).

The skin is colonised by various types of bacteria, but up to 50% of these are Staphylococcus aureus.[64] The most common postoperative superficial wound infection often presents with localised pain, redness and slight discharge, occurring within the first week, usually caused by skin staphylococci.

According to data from the national nosocomial infection surveillance system, the distribution of pathogens isolated from SSIs has not changed markedly during the last decade where Staphylococcus aureus, Coagulase-negative Staphylococci (CoNS), Enterococcus spp. And Escherichia coli remain the most frequently isolated pathogens.[56] Furthermore, nosocomial blood stream infections are usually caused by Gram-positive organisms including Coagulase negative Staphylococcus, S. aureus, Enterococci.[65,66] and these microorganisms nearly always represent true bacteremia such as E. coli and other members of the Enterobacteriaceae, Pseudomonas aeruginosa, and Streptococcus pyogenes.[66] In analyses of contamination rates after cholecystectomy, the main source of wound contamination was found to be the skin of the patient. So post operative SSI can be most commonly occur due to *Staph. Aureus*. However, a research conducted by Yalasin, A.N., *et al*[62] showed slightly different output. According to their findings the commonest causative organisms in 12 surgical wound infection are coagulase-negative staphylococci 21·7%, *Staphylococcus aureus* 19·7%, *Escherichia coli* 19·7%, *Enterobacter* spp. 17·6%, and *Pseudomonas* spp. 10·7%.

Patients undergoing colorectal operations, the degree of contamination was assessed by the recovery of Enterobacteriaceae spp. or *Staphylococcus aureus* in peritoneal irrigation fluid using dip-slides. Intraoperative contamination was strongly associated with postoperative infection.[67] Another study in Bangladesh in 1992, showed that *Esch. Coli* was the major pathogen (60.0%) in the postoperative infection followed by *Staph. Aureus.*

RISK FACTORS OF SSI

Patient and operation characteristics that may influence the risk of SSI development may be listed in order. These characteristics are useful in two ways:

1. they allow systematic approach of operations, making surveillance data more comprehensible; and,
2. knowledge of risk factors before certain operations may allow for targeted prevention measures.

For example, if it is known that a patient has a remote site infection, the surgical team may reduce SSI risk by scheduling an operation after the infection has resolved. A guideline[56] lists the other risk factors which substantially affect the surgical infection in different way.

LIST OF RISK FACTORS

- Age
- Nutritional status
- Diabetes
- Smoking

- Obesity
- Coexistent infections at a remote body site
- Colonization with microorganisms
- Altered immune response
- Length of preoperative stay
- Operation
- Duration of surgical scrub
- Skin antisepsis
- Preoperative shaving
- Preoperative skin prep
- Duration of operation
- Antimicrobial prophylaxis
- Operating room ventilation
- Inadequate sterilization of instruments
- Foreign material in the surgical site
- Surgical drains
- Surgical technique
- Poor hemostasis
- Failure to obliterate dead space
- Tissue trauma

The US Centres for Disease Control's (CDC) NNIS (National Nosocomial Infections Surveillance) risk index is the method of risk adjustment most widely used internationally.[61] Risk adjustment is based on three major risk factors:

1. The patient's state of health before surgery is reflected The American Society of Anesthesiologists (ASA) score, reflecting
2. Wound class, reflecting the state of contamination of the wound
3. Duration of operation, reflecting technical aspects of the surgery.

ASA SCORE

The ASA physical status classification is a system for evaluate the fitness of patients before surgery.

ASA classification of physical status

ASA score

Physical status

1. A normal healthy patient
2. A patient with a mild systemic disease
3. A patient with a severe systemic disease that limits activity, but is not incapacitating
4. A patient with an incapacitating systemic disease that is a constant threat to life
5. A moribund patient not expected to survive 24 hours with or without surgery
6. An ASA score >2 is associated with increased risk of wound infection.

WOUND CLASS:

A system of classification for operative wounds that is based on the degree of microbial contamination was developed by the US National Research Council group in 1964. This classification include four classes with an increasing incidence of bacterial contamination and subsequent incidence of postoperative infection.[68] Definitions of four classes are provided below:

1 Clean

The wound is considered to be clean when the operative procedure does not enter into a normally colonized viscus or lumen of the body. Not emergency, non-traumatic, primarily closed; no acute inflammation; no break in technique; respiratory, gastrointestinal, biliary and genitourinary tracts not entered. SSI rates in this class of procedures are less than 2.1%, depending upon clinical variables, and often originate from contaminants in the OR environment, from the surgical team or most commonly from skin.

2 Clean-contaminated

When the operative procedure enters into a colonized viscus or cavity of the body, but under elective and controlled circumstances. It's a emergency case that is otherwise clean; elective opening of respiratory, gastrointestinal, biliary or genitourinary tract with minimal spillage (e.g. appendicectomy) not encountering infected urine or bile; minor technique break. SSI rates in this class of procedures range from 3.3%.

3 Contaminated

When gross contamination is present but no infection is obvious, a surgical site is considered to be contaminated. As with clean-contaminated procedures, the contaminants are bacteria that are introduced by soilage of the surgical field. SSI rates in this class of procedures can exceed 6.4%.

4 Dirty

If active infection is already present in the surgical site, it is considered to be a dirty wound. Pathogens of the active infection as well as unusual pathogens will likely be encountered. SSI rates in this class of procedures can exceed 7.1%. In a survey performed by Ortega, G. *et al.*[69] between 2005 and 2008 using the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) data set where a total of 634,426 cases were analyzed and when classified according to the wound classification the results were obtained as shown in Table C.

Type of SSI	Wound classes			
	Clean	Clean-Contaminated	Contaminated	Dirty
Superficial	1.76%	3.94%	4.75%	5.16%
Deep incisional infections	0.54%	0.86%	1.31%	2.1%
Organ/space infection	0.28%	1.87%	2.55%	4.54%

Table C: Percentage of SSI

However, the researchers concluded that substantially lower rates of surgical site infections in the contaminated and dirty wound classifications were found when compared with literature prior to their research.

DURATION OF THE OPERATION

Duration of surgery is positively associated with risk of wound infection and this risk is additional to that of the classification of operation. The duration of the operation exceeds the 75th percentile of operation time (T point) as determined from the NNIS database. See Table D for the length of time in hours that represents the 75th percentile for some common surgical procedures.

Operation	T Point (hrs)
Coronary artery bypass graft	5
Bile duct, liver or pancreatic surgery	4
Craniotomy	4
Head and neck surgery	4
Colonic surgery	3
Joint prosthesis surgery	3
Vascular surgery	3
Abdominal or vaginal hysterectomy	2
Ventricular shunt	2
Herniorrhaphy	2
Appendectomy	1
Limb amputation	1
Cesarean section	1

Table D: Duration of Operation

In this study operations that lasted longer than the 75th percentile for the procedure were classified as prolonged.

LENGTH OF HOSPITAL STAY BEFORE SURGERY

Another vital factor is the length of hospital stay before surgery. A hospital might not be free from germs if the environment is not properly maintained and if visitors are not controlled. Prolonged preoperative hospital stay is frequently suggested as a patient characteristic associated with increased SSI risk. More days a patient passes in the hospital before operation, the more the patient is under the increased risk of post operative infection. Therefore, increased length of hospital stay jeopardizes the patient's physical status to point where surgery may inflict infections.

PATIENT-RELATED RISK FACTORS FOR SURGICAL SITE INFECTION

There are several patient-related variables that affect a patient's risk of developing SSI. Some variables, such as age and gender, are obviously not amenable to change or improvement. Fortunately, however, a number of other potential factors, such as nutritional status, smoking, proper use of antibiotics and intraoperative technique, can be improved to support the possibility of a positive surgical result. Some of the more commonly identified patient risk factors for surgical site infection include: pre-existing diabetes and/or perioperative hyperglycemia, obesity or malnutrition, co-existing infection, recent tobacco use, contaminated or dirty wound etc.

Diabetes mellitus

Diabetes mellitus is a risk factor for deep wound infection. In one study, where the Patients were divided into two groups: those with relatively "good" perioperative glucose control (all values ≤220 mg/dL) and those with "poor" control (at least one value >220 mg/dL). In patients with hyperglycemia (>220 mg/dL) on POD 1, the infection rate was 31.3% which was 2.7 times then the infection rate 11.5% in diabetic patients with all serum glucose values <220 mg/dL.[70] So for diabetic patients the serum glucose level is highly recommended to maintain before surgery.

Obesity

Obesity, usually defined as having a body-mass index greater than or equal to 30kg/m^2 is another patient risk factor for SSI that has proven difficult to pin down.

Often there is insufficient time prior to the surgery to significantly reduce the patient's degree of obesity.

Smoking

Nicotine use delays primary wound healing and may increase the risk of SSI. Cigarette smoking has been associated with inhibited wound healing and decreased circulation to the skin due to microvascular obstruction from platelet aggregation and increased non-functioning hemoglobin. In addition, smoking has been found to compromise the immune system and respiratory system.

Pre-existing Remote Body Site Infection

Not infrequently, patients harbor indolent dental, urinary or skin soft tissue infections at the time of surgery. The major concerns about the presence of a pre-existing infection are that it may:

1) be the source for hematogenous spread, causing late infections to joint prostheses or cardiac valves, or
2) be a contiguous site for bacterial transfer. These infections at a site remote from the wound have been linked to increasing SSI rates three- to five-fold.

Extreme of Age

A recent study examined risk factors for SSI among patients who were aged >64 years; the study included 569 patients with SSI and 589 control subjects.[71] The procedures most commonly performed for the study subjects were cardiothoracic procedures (31.5% of all procedures) and orthopedic procedures (22.2% of all procedures). In Japan a large scale survey was conducted to examine risk factors for surgical site infections. One of the purposes of the study was to investigate age as a risk factor for SSIs in gastrointestinal surgery. patient age is a significant predictor for SSIs in some gastrointestinal procedures.[72]

DIAGNOSIS OF SSI

1 Physical exam:

Caregivers will look closely at the wound, including the area around it. He will check for swelling, discharge, and how much tissue is infected. He will also look for other problems or signs of spreading infection.

2 Blood tests:

The blood may be taken from the patient's hand, arm, or IV to find out the present of microorganism in to the blood.

3 Imaging tests:

Pictures of bones and tissues in the wound area may be taken using different imaging tests. Tests may include x-rays, magnetic resonance imaging (MRI), or bone scan. Caregivers use the pictures to look for broken bones, injuries, or foreign objects in the wound area.

4 Tissue biopsy and wound culture:

This is when a small piece of tissue is removed from wound. This sample is then sent to the lab for tests. The sample taken will also be checked to identify the germs in patient's wound. This helps caregivers learn what kind of infection the patient has and what medicine is best to treat it.

TREATMENT OF SSI

There are many methods

Wound care:

1. Cleansing:

This may be done by rinsing the wound with sterile (clean) water. It may be done using high pressure with a needle or catheter and a large syringe. Germ-killing solutions may also be used to clean your wound.

2. Debridement:

This is done to clean and remove objects, dirt, or dead skin and tissues from the wound area. Caregivers may cut out the damaged areas in or around the wound. Wet bandages may be placed inside the wound and left to dry. Other wet or dry dressings may also be used. Caregivers may also drain the wound to clean out pus.

3. Wound cover:

This may also be called a wound dressing. Dressings are used to protect the wound from further injury and infection. These may also help provide pressure to decrease swelling. Dressings may come in different forms. They may contain certain substances to help promote faster healing.

Medicines:

Caregiver may give antibiotic medicine to fight infection. Patient may also be given medicine to decrease pain, swelling, or fever.

Hyperbaric oxygen therapy:

This is also called HBO. HBO is used to get more oxygen into body. The oxygen is given under pressure to help it get into the patient's tissues and blood. The patient may need to have this therapy more than once.

Negative pressure therapy:

This is also called vacuum-assisted closure (VAC). A special foam dressing with an attached tube is placed inside the wound cavity and tightly covered. The tube is connected to a pump which will help suck out excess fluid and dirt from the wound. VAC may also help increase blood flow and decrease the number of bacteria in the wound.

USE PATTERN OF ANTIBIOTICS:

Appropriately administered antibiotic reduces the incidence of surgical wound infection.

Antibiotics have two uses in surgery:

1. To treat established infections.
2. To prevent postoperative infection.

Management of antibiotic in the treatment of surgical infection covers a broad aspect. It is important to recognize the difference between Therapeutic, prophylactic and empiric therapy. Therapeutic antimicrobial therapy prescribed to clear infection by an organism or to clear an organism that is colonisin*g* a patient but is not causing infection. Prophylactic antibiotic should cover the most likely contaminating organisms and be present in the tissues when the initial incision is made and must be given 30-60 minutes before incision. The goal of prophylactic antibiotics is to reduce the incidence of postoperative wound infection. Empiric therapy is the continued use of antibiotics after the operative procedure based upon the intra-operative findings. Patients undergoing high infection rates should receive perioperative antibiotics.

However, treatment, rather than prophylaxis is required in case of pre-existing infection. So Timing of antibiotic administration is critical to efficacy.

1 Prophylactic antibiotics

Prophylactic antibiotics decrease the risk of infection and represents important components of most favourable management of the surgical patient. So errors in antimicrobial prophylaxis for surgical patients remain one of the most frequent types of medication errors in hospitals. The antibiotics selected for prophylaxis must cover the expected pathogens responsible for infection, should achieve adequate tissue levels during operation, cause minimal side effects and be relatively inexpensive.[73]

A prophylactic antibiotic should be used where evidence of benefit exists. Choice of antibiotic depend on type of surgery, area of surgery, etiological agents mostly responsible for wound infections, patient’s physical status and wound class. According to the Antibiotic prophylaxis in surgery (A national clinical guideline) Scottish Intercollegiate Guidelines Network, Prophylaxis antibiotics are highly recommended for Appendicectomy, Colorectal surgery, Caesarean section, Transurethral resection of the prostate, and Arthroplasty surgery to reduces major morbidity, hospital costs.[74] In gynaecology, For prophylaxis, first generation cephalosporins are suitable choices to prevent postoperative sepsis, by E. coli, S. aureus and B. fragilis.[75] Many systematic studies were carried out to measure the relative efficacy of antimicrobial prophylaxis for the prevention of postoperative wound infection in different surgery.

2 Selection of Antibiotic

2.1 Spectrum

The antibiotic chosen should be active against the most likely pathogens. Singleagent therapy is almost always effective except in colorectal operations, small bowel procedures with stasis, emergency abdominal operations in the presence of polymicrobial flora, and penetrating trauma; in such cases, a combination of antibiotics is usually used because anaerobic coverage is required.

2.2 Pharmacokinetics

The half-life of the antibiotic selected must be long enough to maintain adequate tissue levels throughout the operation.

2.3 Administration

Dosage, route, and timing

A single preoperative dose that is of the same strength as a full therapeutic dose is adequate in most instances. The single dose should be given IV immediately before skin incision. Administration by the anesthetist is most effective and efficient.

Duration

A second dose is warranted if the duration of the operation exceeds either 3 hours or twice the half-life of the antibiotic. No additional benefit has been demonstrated in continuing prophylaxis beyond the day of the operation, and mounting data suggest that the preoperative dose is sufficient. When massive hemorrhage has occurred (i.e., blood loss equal to or greater than blood volume), a second dose is warranted. Even in emergency or trauma cases, prolonged courses of antibiotics are not justified unless they are therapeutic.[76,77]

2.4 Efficacy of Prophylaxis Antibiotic

The combination of ciprofloxacin plus metronidazole as well as several ß-lactum based regimens are commonly used regimens for the treatment of patients with such infections.

A study, performed on 509 patient of abdominal surgery, evaluated the efficiency of co-amoxiclav compared with cefuroxime plus metronidazole for the prevention of postoperative wound infections .In the study, 230 patients were given co-amoxiclav with and this came up with a total wound infection rate of 5.6%. Additionally, 225 patients were given cefuroxime plus metronidazole and that resulted in a total wound infection rate of 3%. It is noteworthy that the difference between infection rates was not significant.[78]

In a Prospective study on 580 patients undergoing arterial surgery involving the groins was done to evaluate the efficacy of oral ciprofloxacin compare with IV cefuroxime as a prophylaxis. The patients were divided into two groups, and on the day of surgery one group was given ciprofloxacin 750 mg × 2 p.o. and the other one taken cefuroxime 1.5 g × 3 i.v. The wound infection rate in the ciprofloxacin group was 9.2% (27 patients) and in the cefuroxime group 9.1% (26 patients). The infection rate was similar in the two groups. Thus, oral administration of ciprofloxacin is an attractive, cost-effective and safe alternative to prophylaxis in vascular patients capable of taking oral medication on the day of surgery.[79]

IMPACT OF SSI

Infection is an important cause of morbidity in postoperative patients even though surgical procedure and antibiotic therapy keep on improving. Surgical site infections have many adverse effects on patient's health and economy. Surgical site infections (SSIs) result in up to $10 billion in costs every year.

Compared to an uninfected patient, the patient with an SSI:

- Stays hospitalized 7 days longer;
- Is 60% more likely to spend time in the ICU;
- Is 5 times more likely to be readmitted within 30 days of discharge;
- Is twice as likely to[80]

The likelihood of infection varies by type of surgical incision site and the physical status of the patient. The wound classification system designed by the CDC classifies the increased risk and extent of bacterial contamination during the surgical procedure depends on four separate classes of procedures, which are Clean, Clean-contaminated, contaminated, and Dirty. Prophylaxis is uniformly recommended for all clean-contaminated, contaminated and dirty procedures. It is considered optional for most clean procedures, although it may be indicated for certain patients and clean procedures that fulfil specific risk criteria.

A wide variety of risk factors for surgical site infection after operations have crucial influence on patient's health. The percentage of surgical patients with diabetes can be much higher, depending on the type of surgery being performed. Surgical site infections are not uncommon to the patients with diabetes following operations, and they can be associated with serious morbidity, mortality, and increased resource utilization. The accurate identification of risk factors is essential to develop strategies to prevent these potentially devastating infections Another vital factor is the length of hospital stay before surgery. A hospital might not be free from germs if the environment is not properly maintained and if visitors are not controlled. Prolonged preoperative hospital stay is frequently suggested as a patient characteristic associated with increased SSI risk. More days a patient passes in the hospital before operation, the more the patient is under the increased risk of post operative infection. Therefore, increased length of hospital stay jeopardizes the patient's physical status to point where surgery may inflict infections.

In India, some hospitals are surely ensuring state-of-the art surgery procedure and environment to reduce the risk of post-operative infections but there are many instances in many parts of the country that hospital-environment are not up to the mark to restrain the spread of germs which in turn can increase the risk of post-operative infection rates. A recent study revealed that in India, the occurrence of SSI ranged from 11% to 30%.[59] The present study addresses the issue regarding use of antibiotic as pre-operative, peri-operative and post-operative medication in the management of post-operative surgical site infection in the context of India.

METHODOLOGY

STUDY SITE

The study was conducted at department of surgery in B.L.D.E.U's Shri. B. M. Patil Medical College, Hospital and Research Centre Vijayapur, during the period of Oct 2015 – June 2017.

STUDY POPULATION

All the patients having confirmed diagnosis of acute appendicitis and meeting the inclusion criteria of the study, willing to participate in study and undergoing open surgery by Mac Burney's incision were included in our study.

STUDY DESIGN

Hospital based prospective case control study.

SAMPLE SIZE

- A study titled Perioperative Hyperoxygenation and Wound Site Infection Following Surgery for Acute Appendicitis By Bickel A, Gurevits M, Vamos R, Ivry S, Eitan A found in their study that the mean $\pm$SD of duration of hospital stay in study group was 2.51 ± 0.88 and in control group it was 2.92 ± 1.51[(1)].
- Considering the common SD as 1 at 95% confidence level and at 80% power in the study the sample size is 180, in each group 90 cases were allocated alternatively.

Formula for estimating Sample Size; $$n = \frac{(Z_\alpha + Z_\beta)^2 \times 2 \times SD^2}{d^2}$$

Where,

Z_α = Z value at α level

Z_β = Z value at β level

SD = Common SD

d = Difference between two parameters

TIME FRAME TO ADDRESS THE STUDY

October 2015 – June 2017.

INCLUSION AND EXCLUSION CRITERIA

Inclusion Criteria

- Patients having clinical diagnosis of acute appendicitis confirmed by laboratory investigations and USG. If any doubt CT Scan may be used to confirm the diagnosis.
- All age groups and gender.

Exclusion Criteria

- Immunocompromised status (HIV Positive/On Antineoplastic drugs/On Steroids)
- Uncontrolled Diabetes
- Local skin lesions (Eczema/Tinea etc)
- Perforated and Gangrenous Appendix.

INVESTIGATION DONE IN THIS STUDY:

- Complete Blood Count
- Urine Routine
- Blood sugar
- Blood Urea
- Serum Creatinine
- HBsAg
- HIV

IMAGING MODALITIES

Ultrasound

Ultrasound examination is the first line of imaging modality used to confirm the diagnosis of acute appendicitis. All patients underwent ultrasound examination by a qualified Sonologist in the department of radio diagnosis, in BLDE Hospital. The patient was examined in supine position using a high frequency linear transducer. Machines used were GE LOGIC S 700, Probe- LA 39 and LA 379, with multi frequency transducers (5-12 MHz), VOLUSON Phillips.

CT scan study of abdomen was the second preference to confirm the diagnosis.

PATIENT SELECTION:

The patient undergoing open appendicectomy will be divided in Two groups in the following way

1. Every first patient – Control Group
2. Every second patient – Study Trial Group

STUDY PROTOCOL:

Case were prepared for surgery after preoperative correction of anaemia, hypertension, diabetes and local skin conditions, all the patients underwent surgical procedure after following preoperative preparation.

- Informed written consent was obtained after explaining the surgical procedure, complications and results.
- Nil by mouth 6 hours prior to surgery.

- Injection tetanus toxoid 0.5ml IM was given to all patients before shifting to operation theatre.
- Injection xylocaine sensitivity test was done in all patients.
- Preparation of the parts by shaving was done in wards for all patients before shifting to operation theatre.

ANTIBIOTICS

We have standard protocol for antibiotics with aim to cover gram negative and anaerobic bacteria. All patients in both the groups received preoperative intravenous prophylactic antibiotics against gram-negative and anaerobic bacteria in combination of Ofloxacin 200mg and Ornidazole 500mg intravenous injection was used. In study group only one dose of prophylactic antibiotic was given and in study group those patient who developed SSI received antibiotics according to culture sensitivity. In control group one dose of prophylactic antibiotic was given and continued postoperative for 3 days. Modification of antibiotics was done in those patients who developed SSI according to culture sensitivity.

ANAESTHEASIA

All procedures were performed under spinal anaesthesia. Patients were given SA in left lateral or sitting position depending on the built of patient. All spinal anaesthesia were given by residence not less than second year residency under supervision of assistant professor/professor.

Anaesthetic agent used for spinal anaesthesia contains Heavy Bupivacaine 15mg with Buprenorphine 120mcg, dosage was altered depending on age and built of the patient and level of block was T6 dermatom level.

PERIOPERATIVE OXYGENATION

In the control group, the patients received oxygen from the room air, while in the study group, the fraction of inspired oxygen (FIO_2) reached 80% with the use of nonrebreathing mask with 10lit/min oxygen flow.

SURGERY

After induction of anaesthesia patient was prepared for open appendicectomy by Mc Burney's approach. Operative site was painted with betadine and spirit. Appropriate drapping was done with autoclaved linen supplied by the CSSD of the hospital. All surgeries were done by residence not less than second year residency under supervision of assistant professor. Following resection of the inflamed appendix, the surgical wound in the right lower quadrant of the abdomen is meticulously irrigated and sutured with absorbable sutures. The skin is closed using non absorbable suture material. Use of drain was decided by the surgeon on table as per individual case. Operative time was noted from skin incision to closure of the skin. The specimen after extraction was sent to histopathological examination (HPE) using formalin. It was reported by a senior pathologist in our hospital.

IMMIDIATE POST OPERATIVE CARE AND HYPEROXYGENATION

All patient were shifted to recovery room after the surgery. In the recovery room following completion of the operation, the patients in the study group received high-flow oxygen (10 L/min) through a nonrebreathing mask with a reservoir for 2 hours, while control group received oxygen from room air. After 3 hours in recovery patients were shifted to post operative ward.

SURGICAL SITE EVALUATION

During hospitalization, surgical wound is evaluated daily by Unit team. We used the ASEPSIS (additional treatment, serous discharge, erythema, purulent discharge, separation of deep tissues, isolation of bacteria, and stay in hospital prolonged >14 days) system score to assess the degree of healing and infection of the surgical wound.[1] This scoring method is based on objective, scores, multidimensional parameters, where a greater linear change indicates a greater likelihood of SSI and healing disturbances. Surgical site infection is evaluated clinically according to obvious signs and symptoms such as local induration and erythema, purulent discharge, and the need to explore the wound. Supportive results include increase white blood cell count, fever, radiological evidence of infectious collection, positive culture findings, and resolution of mild infectious findings following antibiotic treatment.

After patient discharge, further wound evaluation was done at the surgical outpatient clinic within 2 weeks after surgery; when necessary additional visits were scheduled.

The primary end point was SSI within 14 days of surgery. The secondary end point was the duration of postoperative hospitalization.

STATISTICAL ANALYSIS

All characteristics were summarized descriptively. For continuous variables, the summary statistics of mean, standard deviation (SD) were used. For categorical data, the number and percentage were used in the data summaries. Chi-square

(χ^2)/ Freeman-Halton Fisher exact test was employed to determine the significance of differences between groups for categorical data. The difference of the means of analysis variables between two independent groups was tested by unpaired t test. If the p-value was < 0.05, then the results were considered to be statistically significant otherwise it was considered as not statistically significant. Data were analyzed using SPSS software v.23.0. and Microsoft office.

- Diagrams
- Mean $\pm$ SD
- Students Unpaired and Paired Test.
- Chi Square Test / Fisher's Exact Test.

RESULTS

From October 2015, to June, 2017, total 180 patients of having confirmed diagnosis of acute appendicitis are included in this study. To have uniformity in both the groups we excluded all the patients having diabetes and immunocompromised status. We also excluded the patients having clinical evidence and imaging study confirming the diagnosis of perforated or gangrenous appendicitis. Superficial infective skin disease can influence the result, so excluded from the study. All the patients included in study underwent open appendicectomy surgery by Mc Burney's approach. 180 patients were alternately alienated between the study group (90 patients, FIO2 of 0.80) and the control group (90 patients, FIO2 of 0.30). Our institute serves the relatively low and middle socioeconomic group of people. All the patients included in study were having almost similar socioeconomic status.

Control Group	Study Group	Total
90 (50%)	90(50%)	180(100%)

Table 1: Patients in study group and control group

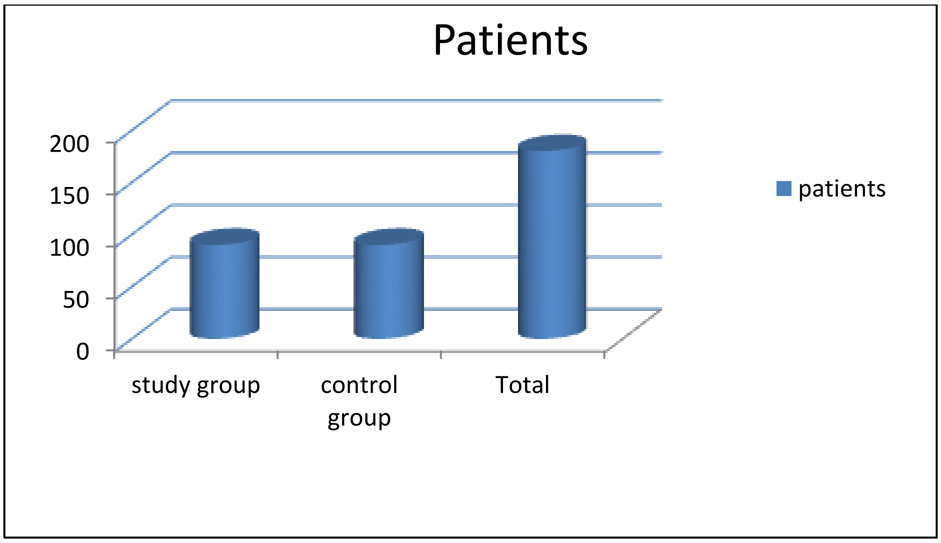

Chart 1: Patients in study group and control group

	Female	Male	Total
Study group	33(36.7%)	57(63.3%)	90(50%)
Control group	47(52.2%)	43(47.8%)	90(50%)
	80(44.45%)	100(55.55%)	180(100%)

Table 2: Sex wise distribution of patients

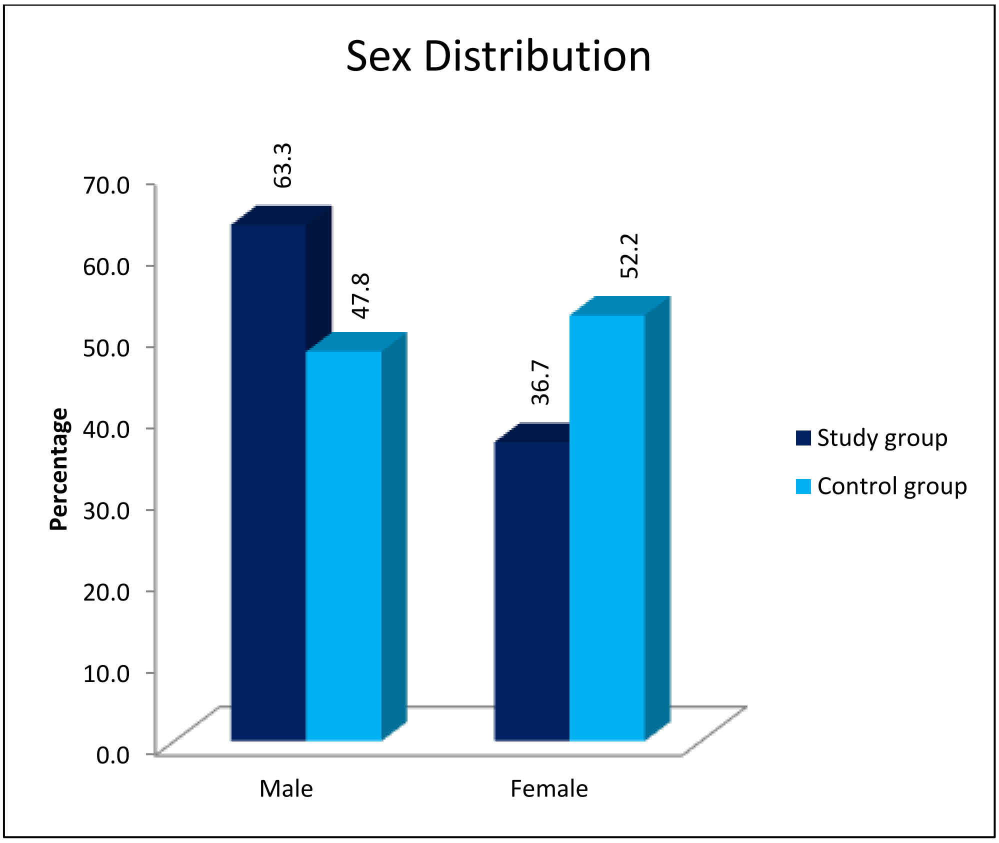

Chart 2: Sex wise distribution of patients

Out of 180 patients included in this study 80(44.45%) patients were female and 100(55.55%) patients were male. In control group out of 90 patients 47(52.2%) patients were female and 43(47.8%) patients were male. In study group 33(36.7%) patients were female and 57(63.3%) patients were male. There is no significant difference in sex wise distribution of patients in both the group (Table 2).

Age (yrs)	Study group		Control group		p value
	N	%	N	%	
≤10	1	1.1	4	4.4	0.578
11-20	23	25.6	20	22.2	
21-30	29	32.2	34	37.8	
31-40	21	23.3	22	24.4	
41-50	10	11.1	6	6.7	
>50	6	6.7	4	4.4	
Total	90	100.0	90	100.0	

Table 3: Age wise distribution of patients

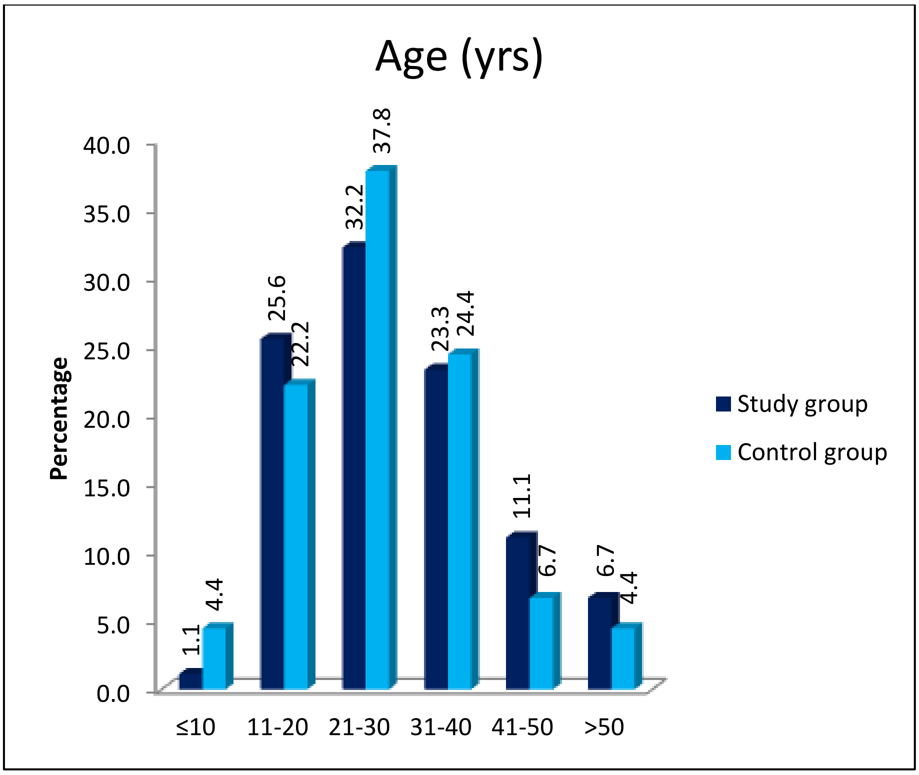

Chart 3: Age wise distribution of the patients

Parameters	Study group		Control group		p value
	Mean	SD	Mean	SD	
Age (yrs)	30.0	12.5	27.8	11.2	0.224

Table 4: Mean age in study and control group

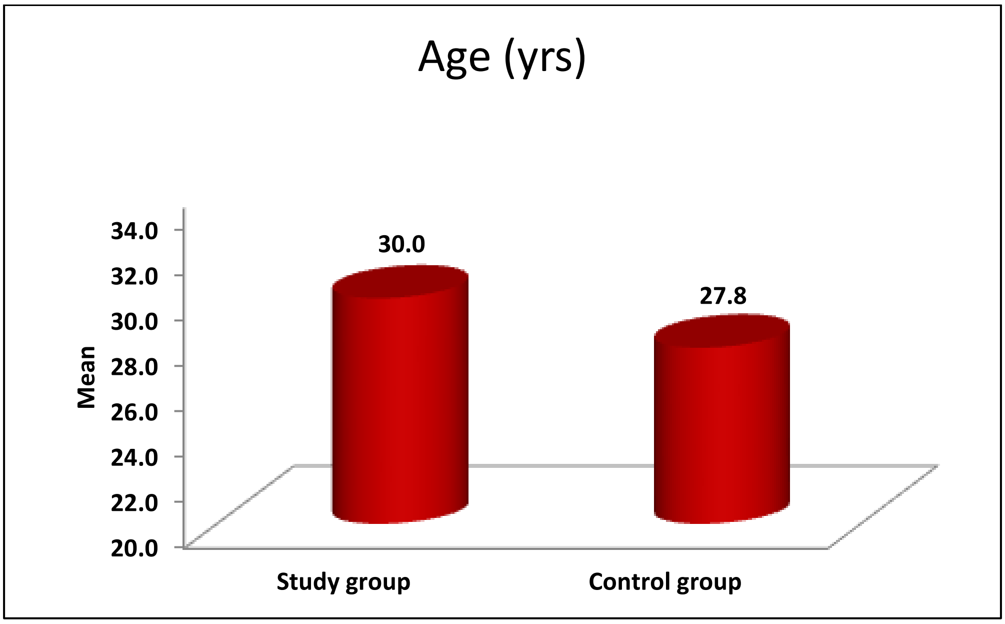

Chart 4: Mean age in study group and control group

In total group range of the age was from 9 yrs to 72 yrs with mean age of 28.9±11.9 yrs. In control group range of the age was from 9 yrs to 62 yrs, with mean age of 27.8±11.2 yrs. In study group range of the age was from 9 yrs to 72 yrs, with mean age of 30.0±12.5 yrs statistically there was no significant differences in age (Table 3-4)

There were no major differences between the groups in medical history, and clinical presentation(Table 5). Parameters such as smoking history, obesity, timing of perioperative antibiotic administration, and abdominal shaving (in the operating room) as well as laboratory results were similar in both groups. Intraoperative hemodynamic parameters and intraoperative findings were not statistically different either (Table 6).

Parameter	Study group		Control group		p value
	N	%	N	%	
Tenderness	90	100.0	90	100.0	-
Rigidity	0	0.0	0	0.0	-
Acute appendicitis	90	100.0	90	100.0	-
Post operative Antibiotics	1	1.1	89	98.9	<0.001*
SSI	5	5.6	17	18.9	0.006*

Table 5: Characteristics of study and control groups

Note: *means significant at 5% level of significance (p<0.05)

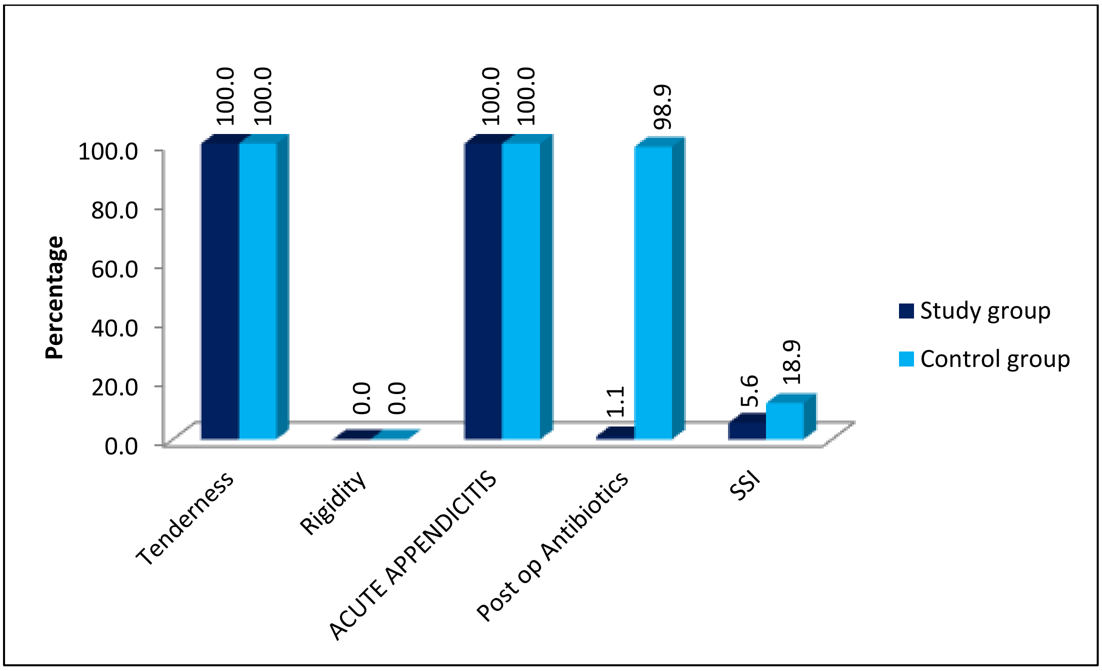

Chart 5: Characteristics of study and control groups

In our study we noticed marked difference in requirement of antibiotic in control group (98.9%) as compare to study group (1.1%) making it significant. In study group 5 (5.6%) patients had surgical site infection ranging from minimal to moderate degree as per ASEPSIS score. In control group 17 (18.9%) patients had surgical site infection ranging from minor to severe degree as per ASEPSIS score.

Parameters related to Surgery	Study group		Control group		p value
	Mean	SD	Mean	SD	
Temperature(°C)	37.9	0.7	37.8	1.3	0.390
Sp02	96.4	1.7	96.7	1.4	0.145
Hb	13.8	10.7	12.2	1.2	0.146
Total count ('000)	9.2	2.6	9.3	2.2	0.842
S.creat	0.8	0.2	0.8	0.2	0.824
Blood urea	22.1	4.1	22.3	7.8	0.887

Table 6: Parameters related to surgery between control and study group

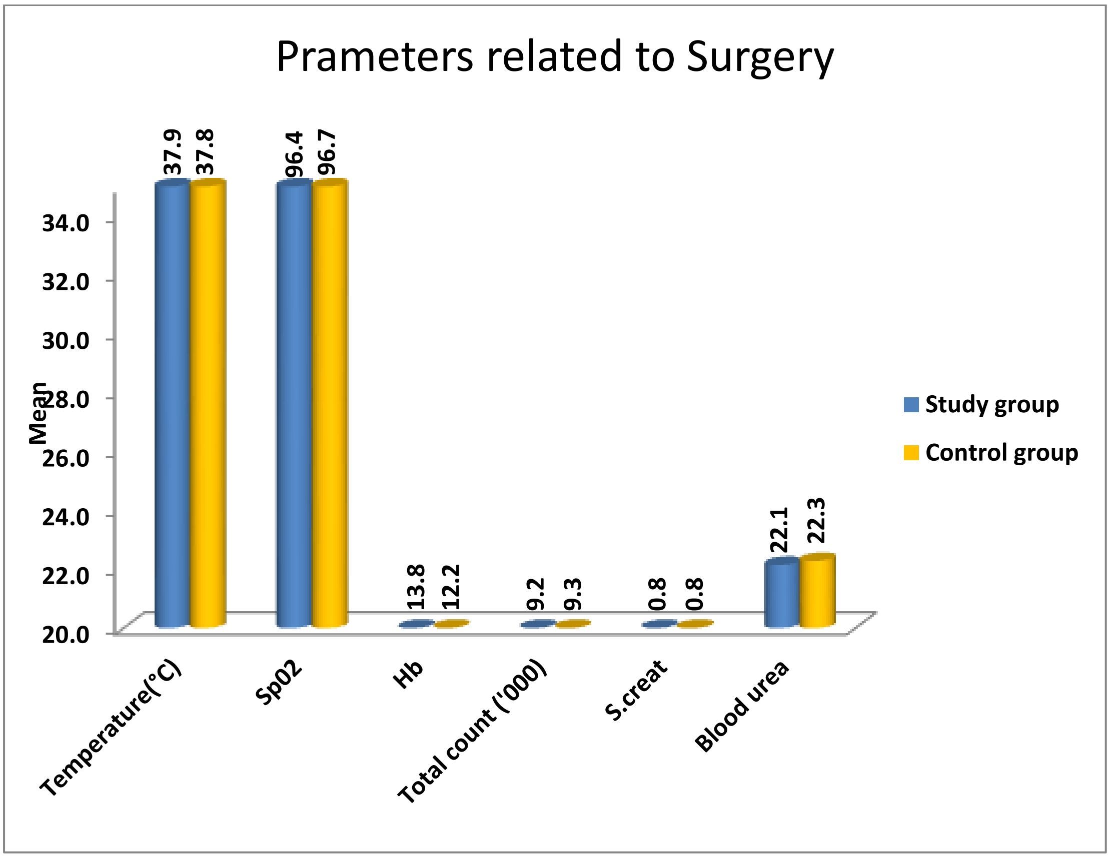

Chart 6: Parameters related to surgery between control and study group

Parameters	Study group		Control group		p value
	Mean	SD	Mean	SD	
Duration of surgery(min)	37.6	4.5	37.8	6.2	0.785

Table 7: Length of Duration of surgery between study and control groups

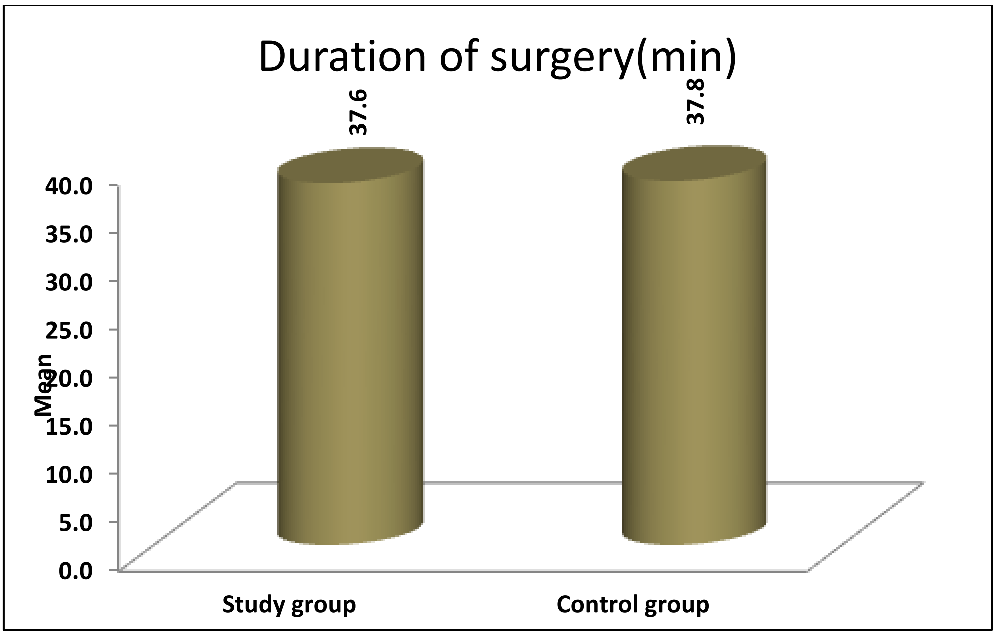

Chart 7: Length of Duration of surgery between study and control groups

All the open appendicectomy surgery was done by different surgeons. We noted operative time from making of an incision to the complete skin closure. Operative time in study group was 37.6 $\pm$ 4.5 minutes and in control group 37.8 $\pm$ 6.2 minutes. There is no significant difference in operative time in both the groups (Table 7).

Average stay in hospital also differs in both the group. Control group has average stay of 7.6$\pm$2 days while study group has 6.4$\pm$2.4 days. Stay in hospital is statistically lower in study group. (p Significance 0.001, table 8).

Parameters	Study group		Control group		p value
	Mean	SD	Mean	SD	
Length of Hospital stay (days)	6.4	2.4	7.6	2.0	0.001*

Table 8: Length of Hospital stay between study and control groups

Note: *means significant at 5% level of significance (p<0.05)

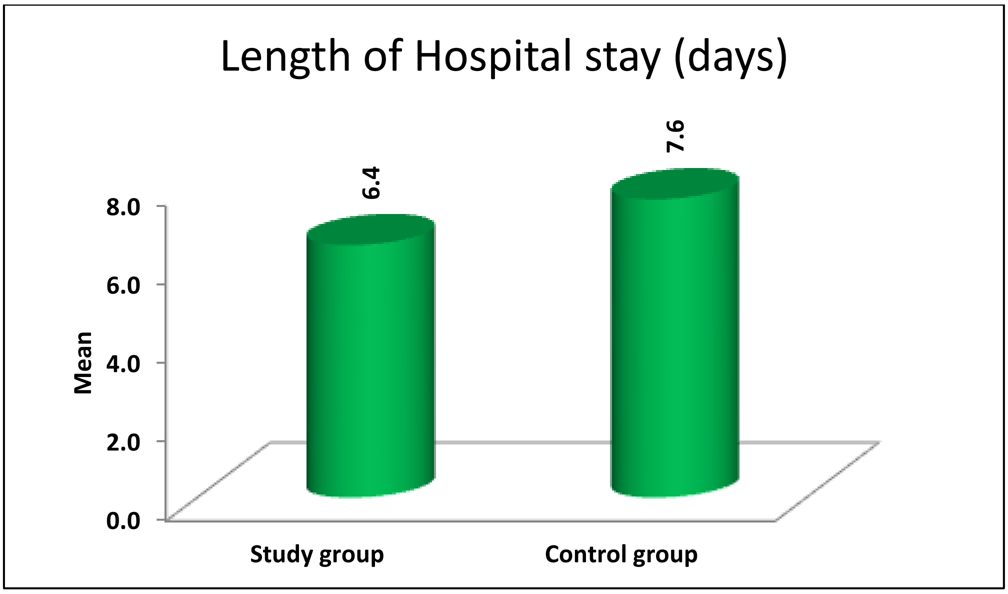

Chart 8: Length of Hospital stay between study and control group

ASEPSIS score interpretation	Study group		Control group		p value
	N	%	N	%	
Disturbance Of Healing	2	2.2	7	7.8	0.093
Minor Wound Infection	2	2.2	5	5.6	
Moderate Wound Infection	1	1.1	3	3.3	
Severe Wound Infection	0	0.0	2	2.2	
Satisfactory Healing	85	94.4	73	81.1	
Total	90	100.0	90	100.0	

Table 9: ASEPSIS score between study and control groups

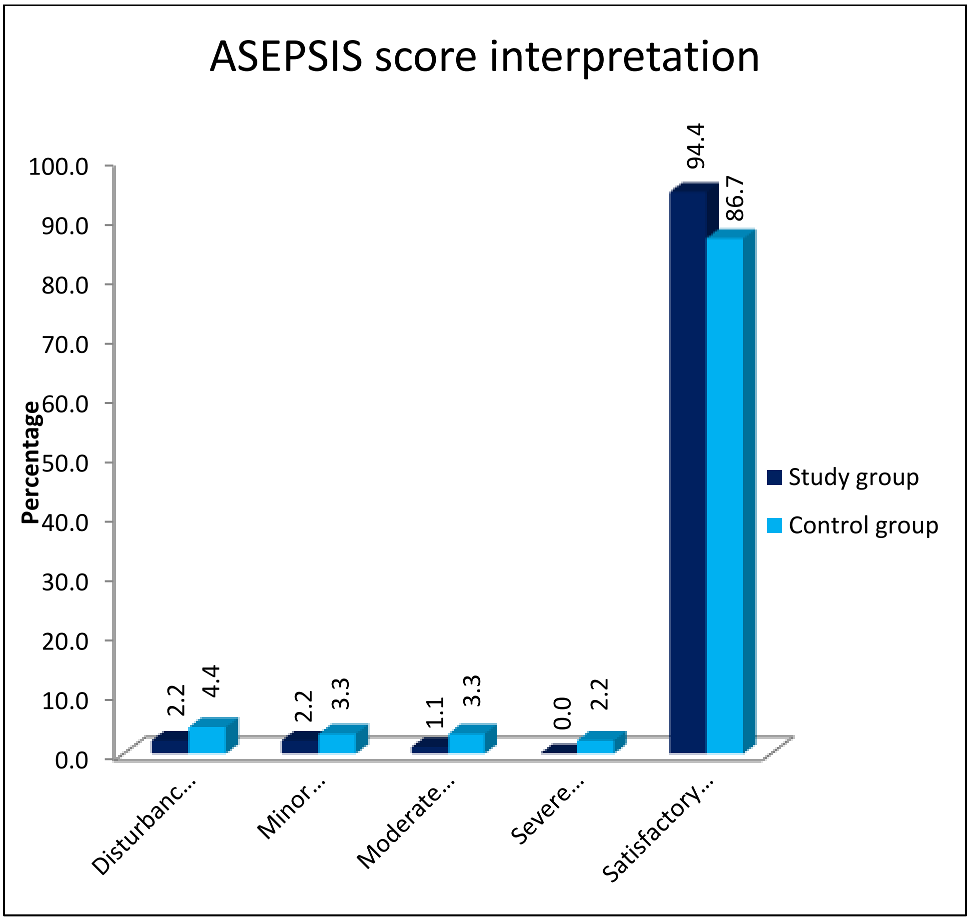

Chart 9: ASEPSIS score between study and control groups

Total Cost of the disposable non rebreathing mask and antibiotics in study group is Rs. 39,240/-, means Rs 436/- per patient. Control group has total cost of 86,580/- means Rs 962/- per head. Cost of treatment in study group is significantly lower than the control group. (Table 10)

	control group	Study group	P value
Mean Cost for antibiotics(Rs)	962	436	<0.001 (sig)

Table 10: cost per patient in study and control group

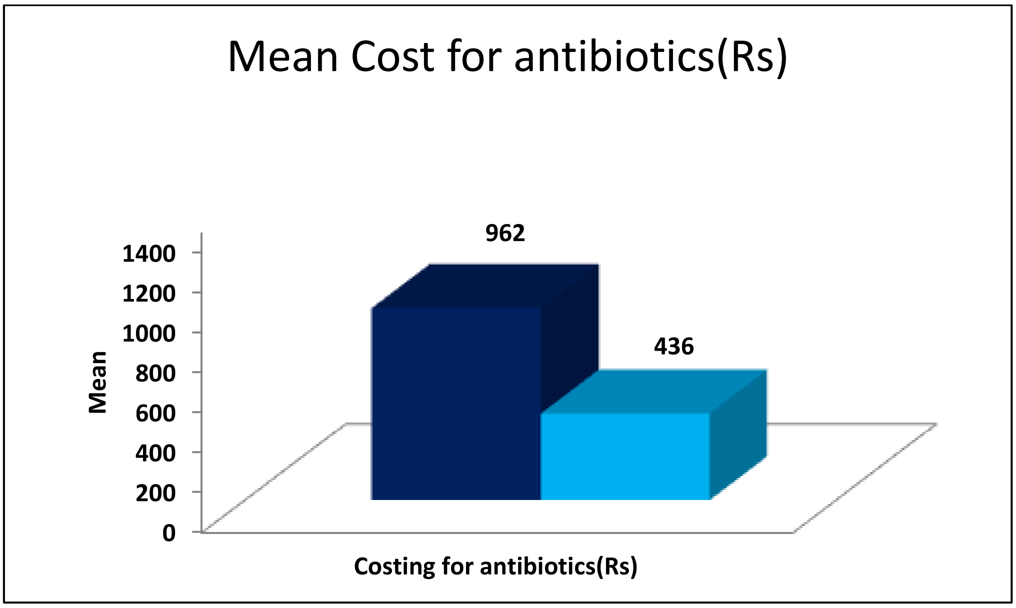

Chart 10: Cost per patient in control and study

No of cases	Day								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Erythema	6	14	2						
Serous Discharge		9	9	3					
Purulent Discharge				1	5		2		
Wound Separation					2		3		
Additional Treatment			1	8	8	3	1		
Isolation of Bacteria							1	1	1

Table 11: No of cases with condition

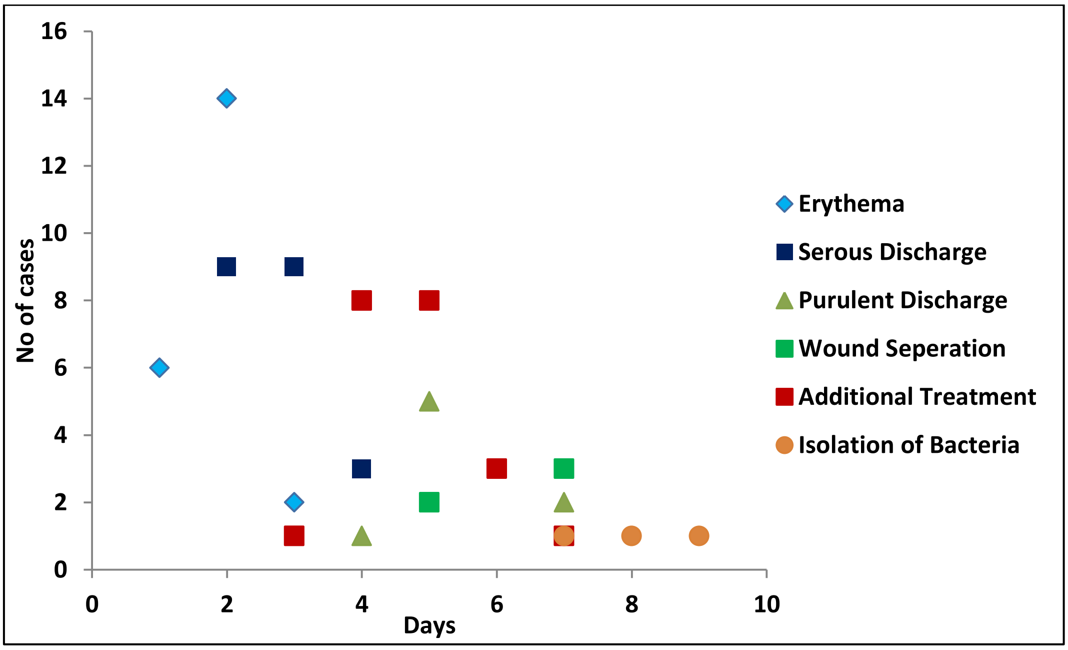

Chart 11: No of cases with condition

Figure 10: Asepsis in control group

Figure 11: Healing in study group

As per Asepsis scoring method erythema was noted on 2nd post operative day in 13 out of 90 patients(14.4%) in control group while only 1 out of 90 patients(1.1%) in study group had developed erythema. 9 patients had serous discharge on 2nd post operative day, 9 patient had on 3rd post operative day and 3 patient had on 4th post operative day. 5 patients had purulent discharge on 5th post operative day. Pus culture was taken for sensitivity study and antibiotics were modified accordingly. In control group 17 patients(18.9%) required additional antibiotics while in study group only 1 patient(1.1%) required additional antibiotics. This is significantly lower in study group as compare to control group.

DISCUSSION

Surgical site infection is a major complication of abdominal surgery, associated with prolonged hospitalization, increased costs and excess mortality. In recent years, randomized trials have identified a number of preventive measures that can substantially reduce the risk of SSI. These include appropriate perioperative antibiotic prophylaxis, maintenance of perioperative normothermia and control of hyperglycemia.[9,81] Achieving high oxygen tension at the site of surgery has been proposed as a means of reducing the risk of SSI, based on data that oxygen can enhance the oxidative processes in white cells, thus facilitating bacterial killing.[9, 24] A number of preclinical studies have shown that provision of high tissue oxygen concentrations promotes local wound healing in animal models. Recent studies in humans have found that administration of supplemental oxygen in the perioperative period to patients undergoing colorectal surgery may reduce the risk of SSI.[13] However, not all studies have found this benefit, and one paradoxically found an increased risk of SSI with supplemental perioperative oxygenation administration.[18] Recent evidence-based reviews and editorials have recommended the use of supplemental perioperative oxygenation for prevention of SSI,[1] but no meta-analysis has systematically quantified the magnitude of the effect.

We studied the role of perioperative hyperoxygenation in patients undergoing open appendicectomy by Mc Burney's incision at BLDE Hospital. We attempted to minimize heterogeneity in the included studies by including only patients that were undergoing open appendicectomy by Mc Burney's incision. Our hospital is located at remote district place, Bijapur. Peoples residing in 50 km radius are taking treatment. The population is mainly from low and middle socio-economy class. It has served in our study of having homogenous mass in both the groups. Our hospital provides almost free medical service to the surrounding population.

Analysis of all the collected data statistically confirmed that there is no significant difference in age, sex, class and clinical presentation. Homogenous population is the important factor in our study.

Analysis of our results demonstrated statistically decreased rate of surgical wound site infection following administration of perioperative hyperoxygenation in patient undergoing open appendicectomy. Our result correlates with many studies like Bickel A et all, Qadan M et all, Schietroma M et all favouring perioperative hyperoxygenation is beneficial to prevent SSI. Significant point in our study is homogenicity in patient population with same type of surgery as compare to the other literature.

Prolonged operative time is one of the factors which predispose the surgical wound to the infection. As per guideline from NNIS operative time in both the group was below 75 percentile. This eliminates the factor of prolonged surgery time in our study.

We used ASEPSIS scoring method and it is one of the easy and reliable system to judge the surgical site infections. Moreover we included the patients of acute appendicitis operated by Mc Burney's incision, so it's easy to judge and compare the same right lower abdomen incision in all the patients. In our studies we used single dose of pre operative antibiotics in study group as compare to 3 days antibiotics in control group. In spite of that just providing perioperative hyperoxygenation SSI could be reduced to significant level, avoiding unnecessary usage of antibiotics. As such we are all worried about development of drug resistance due to unnecessary usage of antibiotics. Recent report by WHO on antibacterial agents in clinical development show serious lack of newer antibiotics to combat the growing threat of antimicrobial resistance. WHO also remark that antimicrobial resistance is global health emergency and will seriously geopardize the progress in modern medicine. Our study justifies the use of perioperative hyper oxygenation to avoid unnecessary use of antibiotics and at the same time reducing cost to the patient.

Hospital atmosphere is one of the common place to spread cross infection and thereby developing drug resistance. Our study demonstrated that study group has significantly lower hospital stay as compare to the control group. Just providing perioperative hyperoxygenation can reduce the post operative stay ; resultant decrease in the chances of cross infection and decrease in financial burden to our charitable hospital. Moreover early discharge in the study group makes the beds free for other waiting patients.

As per our protocol we used maximum Fio2 of 80% to provide hyperoxygenation. There was no reported adverse event showing significant difference in pulmonary complications or other adverse effects.[12,82]

Limitation of this study is that open appendicectomy surgeries were done by different surgeons. Though approach and incision is same, there may be difference in intraoperative tissue handling skill. It could not be eliminated in this study. However it remained same for both the groups.

CONCLUSION

Surgical site wound infection is nightmare for the surgical team. Multifactorial approach is needed to prevent it. Several core SSI prevention strategies have been promoted including the appropriate choice and timing of antimicrobial prophylaxis, avoiding shaving surgical site hair, maintaining perioperative normothermia and controlling perioperative blood glucose.[18] Most of the providers associated with quality improvement. We tried one of the methods, perioperative hyperoxygenation, to reduce the surgical site wound infection at our hospital. Hyperoxygenation uses hyperbaric oxygen in ischemia-reperfusion to protect against oxidative stress and may reduce infection rates by interfering with proinflammatory processes.

We conclude that use of perioperative hyperoxygenation is advantageous in reducing the surgical site wound infections in open appendicectomy surgery. As this is the most common emergent operation in general surgery, decreasing the rate of SSI carries significant clinical and economic gains. In addition, our study was conducted in a relatively homogenous study population, our results support the beneficial effects of perioperative hyperoxygenation in clean-contaminated surgery in general.

SUMMARY

- The study was done at Department of general surgery, M.B.Patil Medical college, B.L.D.E., Vijayapura, from October 2015 to June 2017.
- Total 180 patients of acute appendicitis were included after strict exclusion and inclusion criteria to maintain the homogenicity of the study.
- The operation was performed through the McBurney incision , with the decision to operate based on clinical criteria with supported blood chemistry and imaging modalities.
- All surgeries were performed under spinal anaesthesia using inj Bupivacaine.
- Patients were allotted alternatively to study group and control group.
- Study group patients were given single dose antibiotic preoperatively, while in control group patients antibiotics were extended to 3 days postoperatively.
- Patients in the study group received high-flow oxygen through Rebreathing mask and those in the control group received oxygen from air to achieve levels of a fraction of inspired oxygen (FIO_2) of 80% and 20%, respectively.
- SSI was evaluated by daily wound examination during the hospital stay period, maximum up to 14 days by surgeon.
- ASEPSIS criteria were used to determine the wound site infection and scoring was given accordingly.
- Out of 180 patients 90 (50%) patients were included in study group and 90 (50%) patients in control group. Strict protocols were followed to make both the group homogenous.
- There was significant difference in ASEPSIS score between two groups. SSI developed in 5 (5.6%) patients in the hyperoxygenation group vs 17 (18.9%) in the control group (p 0.006).

- Hospital stay was less in study group. Hospital stay in study group was 6.4 ± 2.4 days while in control group 7.6 ± 2.0 day. (p 0.001)
- Requirement of antibiotics were much higher in control group as compare to study group($p<0.001$).
- We concluded that the use of perioperative hyperoxygenation is associated with lower SSI, shorter length of hospital stay and decrease the use of antibiotics in patients undergoing acute appendicectomy.

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ANNEXURES

ETHICAL CLEARANCE CERTIFICATE

B.L.D.E.UNIVERSITY'S

SHRI.B.M.PATIL MEDICAL COLLEGE, BIJAPUR – 586103

INSTITUTIONAL ETHICAL COMMITTEE

No/58/2015
20/11/15

INSTITUTIONAL ETHICAL CLEARANCE CERTIFICATE

The Ethical Committee of this college met on 17-11-2015 *at* 03 pm *scrutinize the Synopsis of Postgraduate Students of this college from Ethical Clearance point of view. After scrutiny the following original/corrected and revised version synopsis of the Thesis has accorded Ethical Clearance.*

Title "Effects of perioperative hyperoxygenation on surgical site infection in patients with acute appendicitis"

Name of P.G. Student : Dr Harsh Pravinbhai Patel
Dept of Surgery.

Name of Guide/Co-investigator : Dr Vijaya Patil
Professor

DR.TEJASWINI VALLABHA
CHAIRMAN

CHAIRMAN
Institutional Ethical Committee
BLDEU's Shri B.M. Patil
Medical College,BIJAPUR-586103.

Following documents were placed before E.C. for Scrutinization.
1)Copy of Synopsis/Research Project
2)Copy of informed consent form.
3)Any other relevant documents.

SAMPLE INFORMED CONSENT FORM:

TITLE OF THE PROJECT	:	EFFECTS OF PERIOPERATIVE HYPEROXYGENATION ON SURGICAL SITE INFECTION IN PATIENTS WITH ACUTE APPENDICITIS.
PG GUIDE	:	**DR. VIJAYA PATIL** M.S. (GENERAL SURGERY) PROFESSOR OF SURGERY DEPARTMENT OF SURGERY
PRINCIPAL INVESTIGATOR	:	**DR. HARSH P PATEL**

PURPOSE OF RESEARCH:

I have been informed that this study is conducted to study the effects of hyperoxygenation on surgical site infection following open appendicectomy in the patient having acute appendicitis.

PROCEDURE:

I am aware that in addition to routine care received I will be asked series of questions by the investigator. I have been asked to undergo the necessary investigations and treatment, which will help the investigator in this study.

RISK AND DISCOMFORTS:

I understand that I may experience some pain and discomforts during the examination or during my treatment. This is mainly the result of my condition and the procedures of this study are not expected to exaggerate these feelings which are associated with the usual course of treatment.

BENEFITS:

I understand that my participation in the study will help to find effects of hyperoxygenation on surgical site infection following open appendicectomy in the patient having acute appendicitis.

CONFIDENTIALITY:

I understand that the medical information produced by this study will become a part of hospital records and will be subject to the confidentiality. Information of sensitive personal nature will not be part of the medical record, but will be stored in the investigations research file.

If the data are used for publication in the medical literature or for teaching purpose, no name will be used and other identifiers such as photographs will be used only with special written permission. I understand that I may see the photograph before giving the permission.

REQUEST FOR MORE INFORMATION:

I understand that I may ask more questions about the study to **Dr. HARSH PRAVINBHAI PATEL** in the Department of General Surgery who will be available to answer my questions or concerns. I understand that I will be informed of any significant new findings discovered during the course of the study, which might influence my continued participation. A copy of this consent form will be given to me to keep for careful reading.

REFUSAL FOR WITHDRAWAL OF PARTICIPATION:

I understand that my participation is voluntary and that I may refuse to participate or may withdraw consent and discontinue participation in the study at any time without prejudice. I also understand that **Dr. HARSH PRAVINBHAI PATEL** may terminate my participation in the study after he has explained the reasons for doing so.

INJURY STATEMENT:

I understand that in the unlikely event of injury to me resulting directly from my participation in this study, if such injury were reported promptly, the appropriate treatment would be available to me. But, no further compensation would be provided by the hospital. I understand that by my agreements to participate in this study and not waiving any of my legal rights.

I have explained to **______________________________________**the purpose of the research, the procedures required and the possible risks to the best of my ability.

______________________ ______________________

Dr. HARSH PRAVINBHAI PATEL Date

(Investigator)

STUDY SUBJECT CONSENT STATEMENT:

I confirm that Dr. HARSH PRAVINBHAI PATEL has explained to me the purpose of research, the study procedure, that I will undergo and the possible discomforts as well as benefits that I may experience in my own language. I have been explained all the above in detail in my own language and I understand the same. Therefore I agree to give consent to participate as a subject in this research project.

____________________________ _______________________

(Participant) Date

______________________________ ________________________

(Witness to signature) Date

PROFORMA FOR CASE TAKING

SL NO: (Control Group / Study Trial Group)

Name :

Age :	Indoor No :
Sex :	UNIT :
Religion :	DOA :
Occupation :	DOO :
Address:	DOD :

Contact No:

Chief Complaints:

Personal History:

Family History:

General Examination:

Temprature:	Pulse:	Respiratory Rate:	
Blood Pressure:	Icterus:	Odema:	SpO2:

Systemic Examination:

P/A Examination: Tenderness:

Gaurding:

Rigidity:

Bowel Sounds:

P/R Examination:

P/V Examination:

Respiratory system:

CV System:

Clinical Diagnosis:

Lab Investigations:

Hb:

TC: **N** **L** **E** **M**

Urine: Albumin: Sugar: Micro:

Blood Sugar: Blood Group:

Blood Urea: HIV:

Serum Creatinine: HBsAg:

Radiology Investigation:

- **Ultra Sonography:**
- **X-RAY Abdomen:**
- **CT Scan Abdomen:**

Final Diagnosis:

Pre operative Antibiotics:

Anaesthesia :

Anesthesiologist: Assisted By:

Premedication: Induction:

Relaxant: Maintain:

Post Anaesthesia Recovery:

Operative Note:

Surgeon: Assisted By:

Incision:

Intraoperative Findings:

Peritoneal Lavage: Yes/ No

Drainage: Yes/ No

Closure:

Post operative addition of Antibiotics:

Additional Remark:

Follow up:

Post Operative Day	1	2	3	4	5	1 Week	2 Week	Remark
Erythema								
Serous Discharge								
Purulent Discharge								
Wound Separation								
Hospital Stay								

Remark:

KEY TO MASTER CHART

SR No – Serial number

F – Female

M – Male

C – Control

S – Study

IP No – Indoor patient number

DOA – Date of admission

DOO – Date of operation

DOD – Date of discharge

USG – Ultrasonography

SSI – Surgical site infection

SH – Satisfactory healing