

Introduction/Abstract

Although relatively uncommon, Ludwig's angina is a potentially life-threatening infection of the submandibular, sublingual and submental spaces. It was first described by Wilhelm Friedrich von Ludwig, a German physician, in 1836, as a gangrenous induration of the soft tissues of the floor of the mouth and neck, with a 'woody' cellulitis. (Winters, 2003). Peak incidence of the disease occurs between the ages of 20 and 40 years, with a male predominance (McMorran et al., 2017).

There are many predisposing factors which are thought to place patients at an increased risk of developing the condition. These include recent dental treatment, dental caries or generally poor dentition, chronic disease such as Diabetes Mellitus, alcoholism, malnutrition, compromised immune systems such as Acquired Immune Deficiency Syndrome (AIDS) or organ transplantation (Candamourty, Venkatachalam, Babu and Kumar, 2012).

This article will examine the aetiology of Ludwig's angina and examine the presentation, diagnosis and treatment of a patient who presented to an out of hours (OOH) streaming area of a local accident and emergency department, with an emphasis of the importance of a multidisciplinary approach and the importance of ongoing education and awareness of health care staff which is crucial for the successful diagnosis, management and treatment of this potentially life-threatening condition.

Key words:

Ludwig's angina, odontogenic, poly microbial, life threatening

Incidence

Since the introduction of antibiotics in the 1940's, advances in surgical approaches and improved oral and dental hygiene, the mortality rate of Ludwig's angina, which once exceeded 50%, has reduced significantly, (Saifeldeen and Evans, 2004; Lai and Pancer, 2012). Today, mortality rates are in the range of 5 -10%, (Lancot, 1996; Balakrishnan and Thenmozhi, 2014) and is now seen as a rare surgical emergency. In a review of deep space neck infections, the incidence of Ludwig's angina was between 4% (Srirompotong and Art-Smart, 2003) and 8% (Eftekharian et al., 2009). This drop in mortality and incidence is due to advances in both preventative and curative health care but has now left many Health Care Practitioners (HCP's) with increasingly limited experience of Ludwig's angina (Saifeldeen and Evans, 2004). As Ludwigs angina can rapidly deteriorate without immediate and adequate treatment, this now limited experience could increase the risk to patients, if a timely diagnosis is not given.

Dental Problems

In one United Kingdom (UK) study it was shown that dental problems were the second most common reason, after drug interactions, that patients telephoned the Emergency Department (ED) seeking advice. The most common dental conditions presenting to ED were dental pain, dental infections, dental and maxillofacial trauma and post-dental treatment related

complications (Samaei, Weiland, Dilley and Jelinek, 2015). These presenting complaints should give rise for consideration that a patient may be presenting with symptoms of the potentially life-threatening condition of Ludwig's angina, and yet, the same study highlighted that only 6% of ED medical staff in England have received any dental training in medical school.

Cost to NHS

In 2015 a UK survey found that 13% of men and 8% of women reported not attending a dentist in the previous 5 years instead, presenting their oral health concerns to their General Practitioner (GP), (Ahluwalia, Crossman and Smith, 2016). The British Dental Association (BDA) has stated that patients accessing ED's with dental complaints, could be costing the National Health Service (NHS) as much as £18 million annually. The BDA also estimates that approximately 600,000 patients a year are seeking treatment from Primary Care, who like ED clinicians, are not equipped to treat dental pain (Durham, 2017). This highlights the need for not only ED Clinicians, but also GP's and Nurse Practitioners (NP's) to recognise the signs of symptoms of dental emergencies such as Ludwig's angina, and provide prompt emergency care to facilitate the best possible outcomes for their patients.

Case Study

Mr Jones, a 46-year-old male entered the Out of Hours (OOH) streaming area of the local ED, presenting with a three-day history of general lethargy and fever, and a significant, rapid onset of tender, bilateral submandibular swelling, drooling saliva and trismus. On history taking, it was noted that Mr

Jones had recently suffered dental pain, which he left untreated, accompanied by a ten-day history of throat discomfort. His observations on arrival showed a pyrexia of 38.6 °C, Heart Rate (HR) of 122 beats per minute (bpm), Respiratory Rate (RR) of 22 breaths per minute, Blood Pressure (BP) 146/88mmHg, and oxygen saturations on air 96% rising to 99% on 15 litres (l) free flow O₂. Although oxygen saturations on arrival were deemed within the lower end of normal limits, in view of the red flag signs of bilateral submandibular swelling, drooling saliva and trismus, O₂ was administered in case of sudden loss of airway. Airway compromise is the leading cause of death in Ludwig's angina (Pak et al., 2017) and airway protection is the foundation stone of treating this condition (Hassan, Leonard and Russell, 2011). On examination there was no notable use of accessory muscles, denoting difficulty in breathing (Innes et al. 2018) and his breathing pattern appeared normal, with no stridor or dyspnoea detected.

Dysphonia was evident during the history taking process, with Mr Jones's daughter affirming that his voice appeared notably distorted. Mr Jones confirmed that he had not visited his Dentist for 'a few years', as he had not noticed any significant dental issues. Shortly after his dental pain commenced, he attempted to attend his Dental Practice but discovered he had been removed from the registered patient list due to lack of attendance. He was aware that he had dental caries but sought no further help or advice regarding this until self-presenting in ED, with submandibular swelling. This swelling was bilateral in presentation and was affecting more than one deep tissue space of the neck.

A study carried out by Srirompotong and Art-Smart (2003), suggested that Ludwig's angina is up to 90% odontogenic in origin. The erosion of enamel allows the introduction of bacteria into the tooth, triggering the most common cause, dental caries. These bacteria may spread firstly into the pulp then to the root and local tissues producing gingivitis or dental abscesses.

Retropharyngeal abscess or Ludwig's angina may result, when this infection spreads to the deep facial planes (Connolly and Rankin, 2010). Common sources of infection relate to dental procedures involving the second and third molars, because the roots of these molars provide a direct route into the mandibular space as they extend into the mylohyoid muscle, (Srirompotong and Art-Smart, 2003).

Anatomy of the submandibular space

Consideration must be given to the anatomy of the submandibular space in order to fully understand the pathophysiology of Ludwig's angina. The cervical fascia of the head and neck offer minimal resistance against infection which can have extremely serious implications for patients. The structure formed by the facial planes forms at least eleven deep spaces offering potential infection sites for deep neck space infections (DNSI's). The deep spaces may be classified based on their relationship to the hyoid bone. There are the spaces located above the hyoid level; peritonsillar, submandibular, parapharyngeal, buccal, parotid and temporal. There are also spaces which fully encompass the circumference of the neck, including; retropharyngeal, prevertebral and

carotid; and the anterior visceral space below the hyoid level, (Kataria et al., 2015).

There are three severe potential complications related to lateral pharyngeal space infections. The first is internal jugular vein thrombosis. The second is erosion into the carotid artery with the third being cranial nerve interference, in-particularly nerves 9-12 and the sympathetic chain, (Lanctot, 1996).

Causes of Ludwig's Angina

Whilst an odontogenic involvement is often a primary cause for Ludwig's angina, clinicians must also be aware of other potential causes, which include peritonsillar abscesses, oral lacerations, open mandibular fractures, submandibular sialadenitis, and tongue piercings (Srirompotong and Art-Smart, 2003). The bacteriology of Ludwig's angina is poly-microbial and predominantly involves the oral flora. The most frequently isolated organisms in patients with the disorder are *Streptococcus viridans* and *Staphylococcus aureus*. Anaerobes are also frequently involved, including *Bacteroides*, *Peptostreptococci* and *Peptococci*, (Lemonick, 2002).

Inflammatory response

Much that is known about inflammation may be explained by considering the complement, kinin and clotting systems. Twenty different proteins are involved in the complement system, and these various chemicals act as a cascade, each one setting off another in the sequence involved in protecting the body against invading microbial agents. The overall results of these chemical

actions increase vascular permeability, promote chemotaxis, engulf invading microorganisms, and through process called lysis, destroy pathogens.

Bradykinin is a chemical substance released by the kinin system. This chemical substance causes smooth muscle tissue to contract, blood vessels to dilate and may result in pain. Like the complement system, the clotting system forms a cascade of thirteen different chemicals resulting in the formation of blood clots, increased vascular permeability and the promotion of chemotaxis for white blood cells. Acute inflammation also involves other substances such as prostaglandins and Leukotrienes. Prostaglandins are derived from the membranes of most cells, and are accountable for pain, fever and further vasodilation. Leukotrienes, which are found in mast cells, promote vascular leakage but not chemotaxis, and cause white blood cells to adhere to damaged tissues, speeding the removal of bacteria and promoting healing (Fallon and Fleming, 2017). It is the release and actions of these chemicals during the acute phase of inflammation, which are responsible for the classical signs of inflammation displayed by Mr Jones, including fever and the swelling and tenderness to the floor of his mouth and submandibular region. These reactions also offer an explanation into the dysphonia Mr Jones was experiencing.

Vocal Sound

When considering the production of sound, consideration must be paid to the structures involved and how the passage of air may be affected by the pathophysiology of these structures. Air passing through the open glottis produces sound waves by vibrating the vocal folds. It is the diameter, length,

and tension of these folds, on which the pitch of the sound depends. The diameter and length are related to the size of a person's larynx, and contracting voluntary muscles, which reposition the arytenoid cartilages relative to the thyroid cartilage, controls the tension. The pitch rises when this distance increases and vocal folds tense. When the distance decreases, vocal folds relax and the pitch lowers. Intelligible sound requires both phonation and articulation. Articulation is the modification of these sounds by other structures such as teeth, tongue and lips to form comprehensible sounds (Martini, Nath and Bartholomew, 2015).

Dysphonia

In Mr Jones's case, the gross swelling of the floor of the mouth, resulting in the lifting and expulsion of his tongue, accompanied by possible swelling further into his larynx, explains his dysphonia, and highlighted a significant potential risk to his airway (Pak et al., 2018; Lai and Pancer, 2018). Airway obstruction is the most life-threatening complication of this condition due to the progressive swelling of the soft tissues, accompanied by the elevation and posterior displacement of the tongue (Candamourty et al, 2012). The management of Ludwig's angina requires three areas of consideration. Firstly, the maintenance of an effective airway, secondly, aggressive antibiotic therapy, and thirdly, decompression of the submandibular, sublingual and submental spaces as required by surgical intervention, (Winters, 2003).

Neck abscesses

Small, or particularly deep abscesses in the neck, cannot always be identified by an ultrasonography, nor does this method of investigation provide the detailed anatomical information required for surgical intervention. Therefore, contrast-enhanced Computerised Tomography (CT) is the method of choice in radiological evaluation of deep neck infections (Celakovsky, Kalfert, Tucek, Mejzlik, Kotulek, Vrbacky, Matousek, Stanikova, Hoskova and Pasz, 2014).

Conservative approach to treatment

A conservative approach to the management of Ludwig's angina has been encouraged for appropriate patients, over the conventional aggressive airway management strategies previously favoured. This includes intravenous (IV) antibiotic therapy, close airway observations and the drainage of any collectable abscess (Hasan, Leonard and Russell, 2011). In such cases, patients should be admitted to a high dependency case setting for continuous airway monitoring. These patients may decompensate rapidly, developing complications including aspiration, pneumonia, empyema, mediastinitis, pericarditis, carotid artery or internal jugular vein thrombosis or erosion, and sepsis, (Filippone, 2004). A recent paper comparing outcomes of conservative treatment versus surgical treatment for Ludwig's angina concluded that there was a higher incidence of airway compromise in the conservative treatment approach (Edetanlen and Saheeb, 2018).

Airway Management

For all patients presenting with this condition, airway management is the key priority (Lai and Pancer, 2018). However, academic research has illustrated that there appears to be a distinct lack of any formal guidelines for airway control for this patient group. The decision to secure the airway remains largely with clinical judgment and experience of the attending clinician. Due to the potential for bleeding and abscess rupture, blind nasotracheal intubation should be avoided in patients with Ludwig's angina. More favoured techniques include orotracheal intubation or fibre-optic nasotracheal intubation. The main priority is the clinician's ability to recognise that any patient presenting with respiratory distress or impending airway obstruction, requires immediate intubation, (Winters, 2007). In this case study, the patient's inability to swallow, apparent by the symptom of drooling, suggests that airway obstruction may be imminent (Lai and Pancer, 2018). A tracheostomy under local anaesthetic is considered the 'gold standard' of airway management in patients with Ludwig's angina. This may however be difficult in patients presenting with advanced onset of infection due to the anatomical distortion of the anterior neck (Candamourty et al, 2012), and, as discussed, the more conservative approaches are now encouraged as a first consideration.

In Mr Jones' case, he was assessed as having a stable airway on arrival into the ED. He was therefore managed conservatively with extremely close monitoring in the 'resuscitation' area of the department. He was placed on 15l high flow oxygen therapy via a facemask, placed into an upright-seated position on the trolley with continuous cardiac and oxygen saturation

monitoring, and IV Metronidazole (500mg) was commenced (Edetanlen and Saheeb, 2018). At this point consideration was given to Mr Jones' observations. He was experiencing tachycardia, tachypnoea, and pyrexia. These observations, accompanied by the history of acute deterioration of functional ability, placed Mr Jones at moderate to high risk of sepsis. Arterial blood gases including lactate, and blood cultures were taken for analysis, accompanied by numerous other laboratory blood investigations including; full blood count, Urea and Electrolytes, Liver function tests and a blood glucose level. A CT scan was arranged, and the Anaesthetist contacted the Ear, Nose and Throat (ENT) Consultant for immediate review. Mr Jones was then transferred to the High Dependency Unit (HDU) for continued airway monitoring, whilst his CT report was analysed and a more formal and detailed plan of care was considered.

Differentials and Diagnosis

The investigations confirmed the diagnosis of Ludwig's angina. In this case, it was the detailed history taking, and obvious significant bilateral submandibular swelling, accompanied by dysphonia, which led an experienced Nurse Practitioner to raise concerns regarding a possibility of Ludwig's angina with both efficiency and certainty, ensuring the best possible outcome for Mr Jones. There are, however, several potential differential diagnoses to consider when assessing a patient presenting with symptoms such as those displayed by Mr Jones. These areas of consideration include Angioneurotic oedema, Cellulitis, Lingual carcinoma, Lymphadenitis, Peritonsillar abscess, Salivary gland abscess and sublingual haematoma

(Lemonick, 2002). Due to the rapid and potentially life-threatening spread of this condition, early diagnosis and interventions are essential to maximise an optimum outcome for patients.

Four criteria have been proposed to aid in this process and distinguish Ludwig's angina from other forms of deep neck abscesses. The infection must occur bilaterally in more than one deep tissue space; produce gangrenous serosanguinous infiltration, with little or no pus; involve connective tissue fascia and muscle but not glandular structures and spread by facial space continuity rather than by the lymphatic system, (Lemonick, 2002). Any patient presenting with symptoms such as those displayed by Mr Jones should be treated as Ludwig's angina, until proven otherwise. In this case, the other differential diagnoses discussed were ruled out when Mr Jones's symptoms were considered against the four criteria noted, and imaging results were analysed.

Communication

During this rapid assessment, monitoring, stabilisation, and treatment initiation, communication played an enormous role in not only liaising between health care professionals within the department, but also explaining procedures and options to Mr Jones and his daughter throughout. When the Department of Health launched the 6 C's of nursing in 2012, it offered the opportunity to reinforce already existing, but sometimes forgotten values and beliefs which should underpin Nursing care wherever it takes place (Department of Health, 2012). Care, compassion, competence,

communication, courage and commitment are all values and behaviours, which should be held in equally high regard by Nurses today. The 6 C's naturally focus on putting the patient at the heart of everything Nurses do. When providing care for Mr Jones and his daughter, the need to provide consideration to all these values was essential. Each stage of the process was explained, and each question was met with compassion and care. The Department of Health defined communication as central to successful caring relationships and to effective team working. Listening is said to be as important as what is said and done and essential for 'no decision about me without me'. Communication is fundamental to a productive and effective workplace, and provides benefits for both those receiving care, and the staff alike, (Health Education England [HEE], 2017; Department of Health, 2012).

Conclusion

Ludwig's angina is a potentially life-threatening, rapidly expanding, diffuse inflammation of the submandibular and sublingual space. Progressive oedema of the tongue, inflammation of the pharynx and inflammatory distension of the fascial planes of the neck can lead to respiratory tract obstruction and death (Edetanlen and Sahee, 2018; Lai and Pancer, 2018; Balakrishnan and Thenmozhi, 2014; Srirompotong and Art-Smart, 2003).

Whilst it may be suggested that dental issues should not be a focus for Advanced Clinical Practitioners (ACP's), the concerning statistics have shown that whilst General Practice and ED's may not be the most appropriate place for these patients to present, this is in-fact where they are attending.

Clinicians must therefore be trained, and prepared to deal with each case appropriately, by being confident to refer patients back to their own dentist for either a routine or urgent appointment, liaise with specialists to consider more unusual or advanced presentations, or in certain instances, such as Mr Jones' case, initiate immediate, potential lifesaving treatment.

There is a great deal of uncertainty regarding the future of the NHS in Britain at present, and many issues should be taken into consideration when discussing patient's expectations and the appropriateness of their access to health care. Poverty is associated with an increase in oral infections. People of a lower socio-economic group are found to be more likely to smoke, have a higher sugary dietary intake, and delay in attending dental services due to requirements to pay (Wingfield, 2015). These factors may all play a part in increased presentations of dental abscesses. The poorest people with the greatest burden of disease have the worst access to dental healthcare; the inverse care law applies as much to teeth as to any body system (Wingfield, 2015). If more in-hours urgent care appointments were commissioned, the British Dental Association (BDA) believes that Dentists could play a significant part in easing the ever-increasing demands on ED's across Britain. It has been put forward to the Chief Dental Officer for England, that if the BDA's proposal to accomplish this was achieved, it would also have the benefit of offering clear guidelines to the NHS 111 service, which emergency dental care services have the current availability and capacity to treat patients (British Dental Association, 2017).

Patients with dental problems frequently present to the ED at weekends and outside normal working hours, when dentists may not be available to offer appointments. An adequate understanding of dental disease and trauma is therefore imperative for clinicians to be able to diagnose, treat and refer patients with dental emergencies efficiently (Samaei et al, 2015). Although Advanced Nurse Practitioners have a limited role in the treatment of Ludwig's angina, their ability to promptly recognise the signs and symptoms of this condition, and therefore initiate prompt emergency care and treatment will facilitate better outcomes for their patients (Winters, 2003).

In Mr Jones's case, early diagnosis from an experienced Nurse Practitioner, and rapid involvement of the multi-disciplinary team were imperative to ensure a safe outcome. This highlights the need for ongoing education and awareness as they are crucial for the successful diagnosis, management and treatment of this potentially life-threatening condition. Early diagnosis, aggressive antibiotic therapy, and management involving a multi-disciplinary team approach are imperative for these patients to progress without complications (Winters, 2003).

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Appendix 1

Age	46 years
Gender	Male
History of presenting complaint and symptom	
<p>3-day history of general tiredness and fever, with worsening face and neck swelling. Difficulty opening his mouth and drooling progressively worsening. Altered voice evident and reportedly becoming more obvious. 10-day history of a sore throat. Recent history of dental pain, with no recent assessments by a dentist. Daughter reports some evidence of confusion in the last 24-48hrs.</p>	
Past medical history	
<p>Possible Diabetes Mellitus - yet to return to the surgery for blood tests to confirm. No known allergies.</p>	
Drug history	
<p>No prescribed medication. Reports taking Paracetamol regularly for the last 6 days. 8 x 500mg tablets in 24hr period (not exceeding the recommended amount). Ibuprofen 6 x 200mg in 24hr period for the last 4 days.</p>	
Social History	
<p>Heavy smoker – 40 cigarettes per day for the past 30 years. Alcohol intake approximately 4 pints of larger per night, sometimes more at the weekend - in excess of 56 units per week. Lives alone, daughter visits regularly.</p>	
Family History	
<p>Mother and father still alive. Father has Diabetes (unsure of age of onset). Mother has Rheumatoid arthritis.</p>	
Investigations and examination findings	
<p>Temp – 38.6 °C, Pulse 122bpm, Resp Rate 22, O2 Sats 96% on air, BP 146/88mmHg. Significant bilateral submandibular swelling noted, with trismus and drooling evident. Tender when neck region palpated. Obvious dysphonia evident, with 'plumb' sounding voice. Slightly disorientated at times.</p>	
Differential Diagnosis(s)	
<p>Ludwig's angina Dental or peri-tonsillar abscess Lymphadenitis</p>	

Potential management /referrals/communication

Immediate airway assessment

15l high flow oxygen therapy commenced – moved into the ‘resus’ area of the ED, and sat in an upright position

On-call Anaesthetist Consultant contacted by ED Consultant and asked to review immediately

Cardiac monitoring commenced

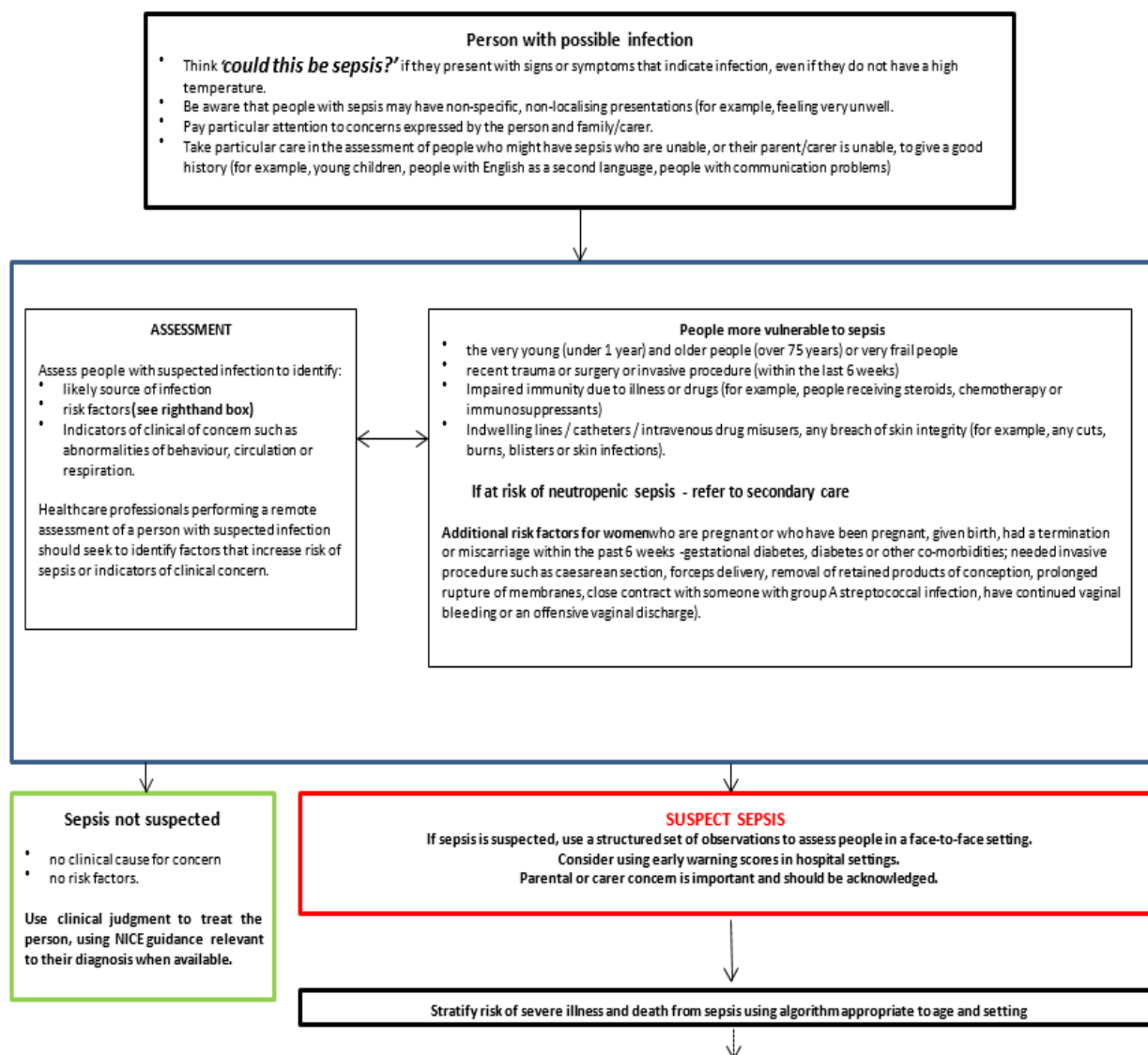
Full bloods including an Arterial Blood Gas requested

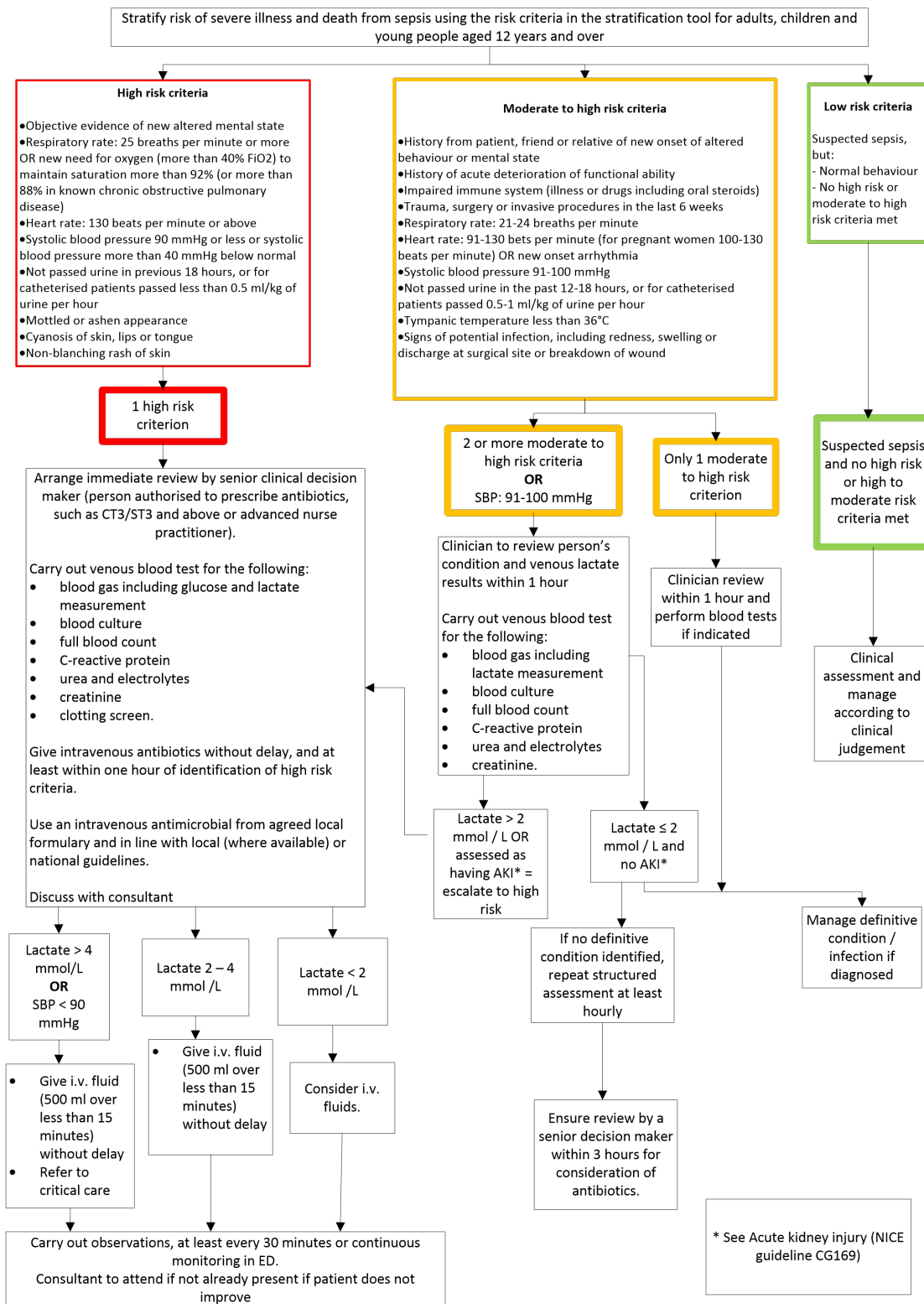
CT scan booked

ENT Consultant contacted

Daughter offered use of the relative’s room with a Health Care Assistant for support. Full explanation of immediate concerns and actions given

Appendix 2





The National Institute for Health and Care Excellence (NICE) (2016)