An audit looking at identifying sepsis in children at Guide Bridge Medical Practice

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List of Abbreviations

Abbreviation	Explanation
Bpm	Beats per minute
EMIS	Egton Medication Information services
EOS	Early onset Sepsis
GBS	Group B streptococcus
LLOS	Late late onset sepsis
LOS	Late onset Sepsis
NHS	National Health service
NICE	National Institute of Clinical Excellence
NO	Nitric Oxide
SIRS	Systemic Inflammatory Response Syndrome
SOFA	Sequential Organ Failure Assessment
TLR	Toll like receptor

Abstract

Sepsis, or septicaemia, is a blood poisoning that occurs as the body responds to an infection by attacking its own organs and tissues. It affects over 150,000 people annually in the United Kingdom, of which 25,000 are children and takes over 44,000 lives each year. These numbers have fuelled efforts in healthcare to improve the detection and management of the disease with the development of definitions over the years. The non-specific nature of the disease has made it difficult to define for decades and consequently diagnose. A raised temperature is one of these non-specific but common features in children with sepsis and must have a routine assessment of heart rate, respiratory rate and capillary refill time recorded for identification. This audit will look at the Guide Bridge Medical Practice to assess how the current National Institute of Clinical Excellence (NICE) guidelines for sepsis are applied in feverish children.

Methods: I searched the electronic database (EMIS) to observe if 100% of children aged 3 months to 5 years, with a temperature > 37.9°C had a routine assessment.

Results: In total 12.5% of patients had a complete routine assessment. Heart rate, respiratory rate and capillary refill time were documented in 53%, 31% and 37.5% patients, respectively.

Conclusion: The findings suggest an inconsistency in routine assessment which may result in inadequate risk stratification for sepsis and management.

Proposals for change: Implement the routine assessment algorithm and re-audit in 12 months.

Background

What is Sepsis?

Sepsis describes an overwhelming response to microbial invasion as the immune system activates a systemic inflammatory response syndrome (SIRS) and presents with a range of non-specific clinical features and symptoms due to physiological changes in the body. (1-3)

The initial infection may be a result of bacteria, virus, fungi or parasitic infiltration. (4) The subsequent inflammatory response aiming to prevent the spread of this invasion by producing complex immunological, coagulation and circulatory changes is life threatening. (1, 4)

Pathophysiology of Sepsis

Sepsis relies on the activation of the innate immune system (the immediate response to infection). This system involves physical barriers, antimicrobial factors (e.g. cytokines), phagocytosis and resultant inflammation. (5) The innate response is initiated by gram positive and negative bacteria which have outer cell products on their membrane that bind to toll like receptors (TLR). These TLRs are found on leukocytes, macrophages and endothelial cells. (5, 6) The system then works by way of a cellular and humoral response.

In the cellular response, binding of TLR causes phagocytosis and the release of inflammatory mediators such as cytokines, prostaglandins and histamine. Some cytokines approach the endothelium to mediate the release of nitric oxide (NO), a vasodilator. (5, 6) This increases blood flow to the source of infection to allow white blood cells localise infection. Cytokines interleukin 1-β and tumour necrosis factor –α also induce fever to inhibit bacterial growth in infection. (5)

Normally, this pro-inflammatory response is regulated by a simultaneous anti-inflammatory process. Sepsis occurs when the pro-inflammatory response is so vigorous that it overwhelms the homeostatic constraints to become systemic. (6) In sepsis, the damaged

and activated endothelium secrete larger amounts of NO causing widespread vasodilatation and decreased vascular resistance, opening up collateral channels through tissues to reduce perfusion and blood flow. (5, 7) This results in hypotension and shunting of blood from the arterial to venous compartment by way of the newly formed collateral channels. (7) The reduced vascular resistance is attempted to be compensated through increasing cardiac output which also raises heart rate. (7) However despite this, tissues and organs become hypoxic and bacteria undergo cellular respiration for an energy source which results in high lactate levels. (7)

The damaged endothelium also causes widespread capillary leak as it becomes porous to large molecules leading to tissue oedema and less circulating volume. (6) This hypovolemia can progress to hypovolemic shock and organ dysfunction such as acute kidney injury. Now we can begin to see some features a septic patient may have: fever, hypotension and tachycardia.

The humoral response involves activation of the complement system. Involving 20 proteins, this system is activated when immunoglobin G or M antibodies bind to bacterial antigens to disrupt its' integrity and leak contents. (8) This also releases protein fragments C3a and C3b attracting more leukocytes to sustain the immune response. (5)

Why is sepsis important?

Sepsis can progress to severe sepsis, septic shock and multiple organ dysfunctions. (7) This accounts for major causes of intensive care unit admissions as mortality rates increase when sepsis progresses. (9) The importance of sepsis is highlighted here as it can quickly develop into even further life threatening complications.

Multiple definitions exist regarding the sepsis terms mentioned previously: SIRS, sepsis, severe sepsis and septic shock. This causes discrepancies in each, partially accounting for the difficulty in diagnosis. (10) The following sections discuss the development of definitions for these terms over the years through conference articles.

1991-An American College of Chest Physicians/Society of Critical Care Medicine Consensus Conference

The first consensus conference regarding sepsis was held in 1991 where we were initially introduced to the sepsis associated terms we use today: SIRS, severe sepsis and septic shock. (11)

Here, Bone et.al (11) originally proposed the term 'SIRS' to collectively describe the inflammatory response to infection, trauma, or other inflammatory processes. The criteria for SIRS were subsequently presented (Figure 1).

SIRS criteria (2 of the following to be met):

- Body temperature >38°C or <36°C
- Heart rate >90 beats per minute (bpm)
- Respiratory rate >20 breaths per minute
- White cell count <400/ mm^3 (Neutropenic sepsis) or >12, 000/mm^3

Figure 1-SIRS criteria (Adapted from 11)

The same conference article recommended a definition for sepsis to include the presence of SIRS with documented infection. In addition, the term ‘severe sepsis’ was introduced: sepsis with organ dysfunction, hypo-perfusion, or hypotension. Although this was used for many years in multiple literatures, the term was made to be redundant in years to come to replace the definition for ‘sepsis’ in 2016. Furthermore, here ‘septic shock’ was described as hypotension with hypo-perfusion unresponsive to adequate fluid resuscitation in sepsis.

Although this conference was a major leap in the field of sepsis and its sequela, it did however fail to acknowledge adults and paediatrics as separate entities. Therefore, criteria were not adjusted for use in the latter. For instance, a heart rate of 100 bpm or a respiratory rate of 30 breaths may be normal in children but since there was no explicit expression that SIRS was adult tailored, it could falsely recognize SIRS in paediatrics.

2001- International Sepsis Definitions Conference

An international conference with participants from Europe and North America was held in 2001 to confer about septic features, SIRS criteria and whether there is a need for changes in the diagnostic criteria of the illnesses. (12)

This conference identified weaknesses in the definitions used in the preceding decade as criteria were too non-specific in identifying a cause to SIRS. Investigations for those who met SIRS criteria set in 1991 (Figure 1) showed elevated levels of inflammatory markers which stemmed goals of using biochemical evidence as opposed to clinical criteria to confirm SIRS. (12)

Organ dysfunction involved earlier in sepsis as opposed to in ‘severe sepsis’ was hypothesized here from assessments in infected patients. Therefore a diagnosis of sepsis newly became concerned with criteria of hemodynamic instability, arterial hypoxemia, oliguria, coagulopathy, and deranged liver function tests. This formed a basis for the Sequential Organ Failure Assessment (SOFA) score to soon replace old SIRS criteria in later years. (12)

The conference also introduced the need for criteria to be applicable to paediatric and neonatal patients in addition to adults. (12) This would be soon followed up by the second international conference in 2005.

2005- International paediatric sepsis consensus conference: Definitions for sepsis and organ dysfunction in paediatrics

The second international conference on sepsis definitions were held specifically in consideration of paediatrics. Five countries (Canada, France, Netherlands, United States (U.S.) and the United Kingdom (U.K.)) formed a panel of experts in sepsis to modify definitions for children. (13) A few questions were addressed at the conference, including; how age groups should be divided when looking at septic features and which criteria must be modified for SIRS and its sequela in children.

How should the paediatric age group be separated when concerning sepsis?

Clinical features attributing to the definitions of SIRS, sepsis, severe sepsis and septic shock depend on normal physiological changes as children age. Thus criteria must be tailored for age groups by way of vital signs. The panel proposed six physiologically different age groups related to corresponding criteria for vital signs. These age groups refer to newborn, neonate, infant, toddler to preschool, school aged and adolescent to young adults. (13) The panel gathered these groups by determining their risks for infections, recommendations for antibiotics and developmental cardio-respiratory changes, specific for each group.

The article did not however, sub-classify each age group like NICE, to account for further physiological changes in each. In today's NICE guidelines regarding sepsis, algorithms are defined by age groups; under 5, 5-11 and 12-17 years. (14) This audit focuses on under 5 years old i.e. 'infant to toddler' for which NICE have even more subsections: < 3 months, < 1 year, 1-3 years and 3-4 years. This makes the limits of physiological changes apparent in such children. Whereas the conference article only divides infants into 1 month – 1 year and

toddler as 2- 5 years old. The latter group is quite large therefore bound to have physiological differences within, needing to be accounted for in criteria.

What are the definitions for SIRS and its related terms in children?

We have discussed the importance of separating age groups for criteria. Next the article addresses the modifiable criteria in SIRS for these children.

The conference highlights the main difference between adults and paediatrics to be a requirement of temperature changes or leukocyte derangement to be present in the latter. (13) Tachycardia and tachypnoea is also a common feature in these children but present in a range of other diseases too. Therefore, SIRS in children requires temperature or leukocyte criteria to be met with either tachycardia or tachypnoea and not diagnosed by just any two of the SIRS criteria as in adults.

The numerical criteria for each category (heart rate, respiratory rate, temperature etc.) must be modified for the proposed age groups in children. Hypothermia (<36°C) automatically indicates high risk for severe illness and sepsis despite the age. Modifications are core temperature >38.5°C (as opposed to > 38°C) or <36°C, heart rate and respiratory rate 2 standard deviations above that of the normal age. (13)

The panel made no specific adjustments in original definitions for sepsis, since it relied on initial SIRS criteria. Thus any changes are only by default. There are however modifications to be made when considering septic shock in children. This is because although the definition of septic shock in adults involves hypotension, children will maintain their blood pressure until decompensated shock. Therefore a description for septic shock in children involves tachycardia (may be absent in hypothermia) and hypo-perfusion.

<u>2016-The Third International Consensus Definitions for Sepsis and Septic Shock (Sepsis-3)</u>

Since the previous two international consensus conferences, a third was held in 2016. (10) Here, it was proposed that a change in sepsis definition was needed as the previous did not

truly explain sepsis. The recommendation for this was ‘a life threatening organ dysfunction caused by a dysregulated host response to infection’. (10, p.801) In the past this definition was reserved for ‘severe sepsis’, however this term has been made redundant. (15) This change was already postulated in the second conference with new criteria. (12) Now, a SOFA score increase of 2 or more is shown to support organ dysfunction (Figure 3). (10)

Signs in sepsis:

- Mottled skin
- Delayed capillary refill time (>3 seconds)
- Abrupt change in mental status
- Lactate>2 mmol/L
- Urine output reduced (Oliguria < 0.5ml/kg for at least 1 hour)
- Platelet count <100 x 10^9/L
- Acute lung injury
- Cardiac dysfunction

Figure 2 -Signs in sepsis (Taken from 15)

SOFA criteria:

- Respiratory (Assessed by PaO_2)
- Neurological (Assessed by Glasgow Coma Scale)
- Cardiovascular (Assessed by mean arterial pressure or vasopressors administration)
- Coagulation (Assessed by platelet count)
- Renal (Assessed by creatinine level and urine output)
- Hepatic (Assessed by bilirubin level)

Figure 3-SOFA score criteria (Taken from 10)

However, the SOFA score is not well known to primary care physicians which means it would be unhelpful in General Practice (GP) as a bedside measure. Hence a 'quick' SOFA (qSOFA) score can be used: change in mental state, systolic blood pressure< 100 mmHg or respiratory rate > 22 breaths per minute. A score of 2 or more supports poor outcomes of sepsis. (10)

Furthermore, septic shock is now understood to be a deterioration of sepsis where underlying cellular and circulatory changes have progressed so much so that persistent hypotension requires vasopressors to maintain an adequate blood pressure. (10) Mortality rates increase by 50% here. (2) This new statement has evolved from the 1991 recommendation of 'hypotension and hypo-perfusion despite adequate fluid resuscitation'. (11)

Conclusion

For the last quarter of a century, literature has shown updates in SIRS criteria to adapt for age groups and incorporate objective evidence as opposed to clinical features alone. In addition, a significant change in the description of sepsis has been made to include evidence of organ dysfunction replacing the redundant term 'severe sepsis'. Finally, septic shock is now recognised to require vasopressors to maintain an adequate blood pressure instead of hypotension and hypo-perfusion alone despite fluid replacement.

Clinical features of sepsis

From the conference articles discussed, we can appreciate septic features vary in individuals especially between paediatric and adults. There are, however, some common features with tachypnoea being one. This is particularly frequent in children but also associated with increase in mortality; it can indicate pulmonary dysfunction as well as respiratory compensation for metabolic acidosis. (16)

From the international paediatrics conference (13) it was said temperature > 38.5 °C or leukocyte derangement must be present for SIRS diagnosis. Therefore it too must be a very common feature within children. Pyrexia may occur as the hypothalamus resets to favour heat production in sepsis for bacterial growth inhibition. (5) This may result in chills due to increased muscle activity in raised body temperature. In some instances, hypothermia (<36°C) may be present instead of pyrexia, which is more predictive of severe illness. (16)

Another sign of sepsis may be tachycardia. (16) This is because the body raises cardiac output to compensate for the reduced vascular resistance in sepsis. (7) In addition, capillary refill time may be delayed in sepsis due to hypo-perfusion. (16) This is a marker for moderate to high risk for sepsis and severe illness as mentioned by NICE. (14)

These features are non-specific as they present in numerous other conditions. Therefore, they are not indicative of sepsis alone but do suggest illness severity and are used in risk stratification by NICE. (14) The clinical picture will also be relevant in confirming a diagnosis. I will look at the use of these signs in this audit for appropriate risk stratification of sepsis in children.

NICE guidelines for septic children

The audit involves NICE guidance NG51 (17) and CG160 (18). The former set of guidelines 'Fever in under 5s' suggests a routine assessment for group of children in question (section 1.2.2.6). (18) This includes the recording of heart rate, respiratory rate and capillary refill time in order to identify serious illness in children using the 'traffic light' table (Table 1). (19)

This guidance is further enhanced for 'Identifying and managing sepsis in children under 5 and out of hospital' in 'Sepsis: recognition, diagnosis and early management'. (17) Here, they state if a person has features of a possible infection, be aware of sepsis and follow the algorithm (Figure 4). The algorithm displays the elements of routine assessment for fever in face to face observations when querying sepsis. It can be used with the 'traffic light' table in identifying risk of serious illness or with the risk stratification table for sepsis (Table 2).

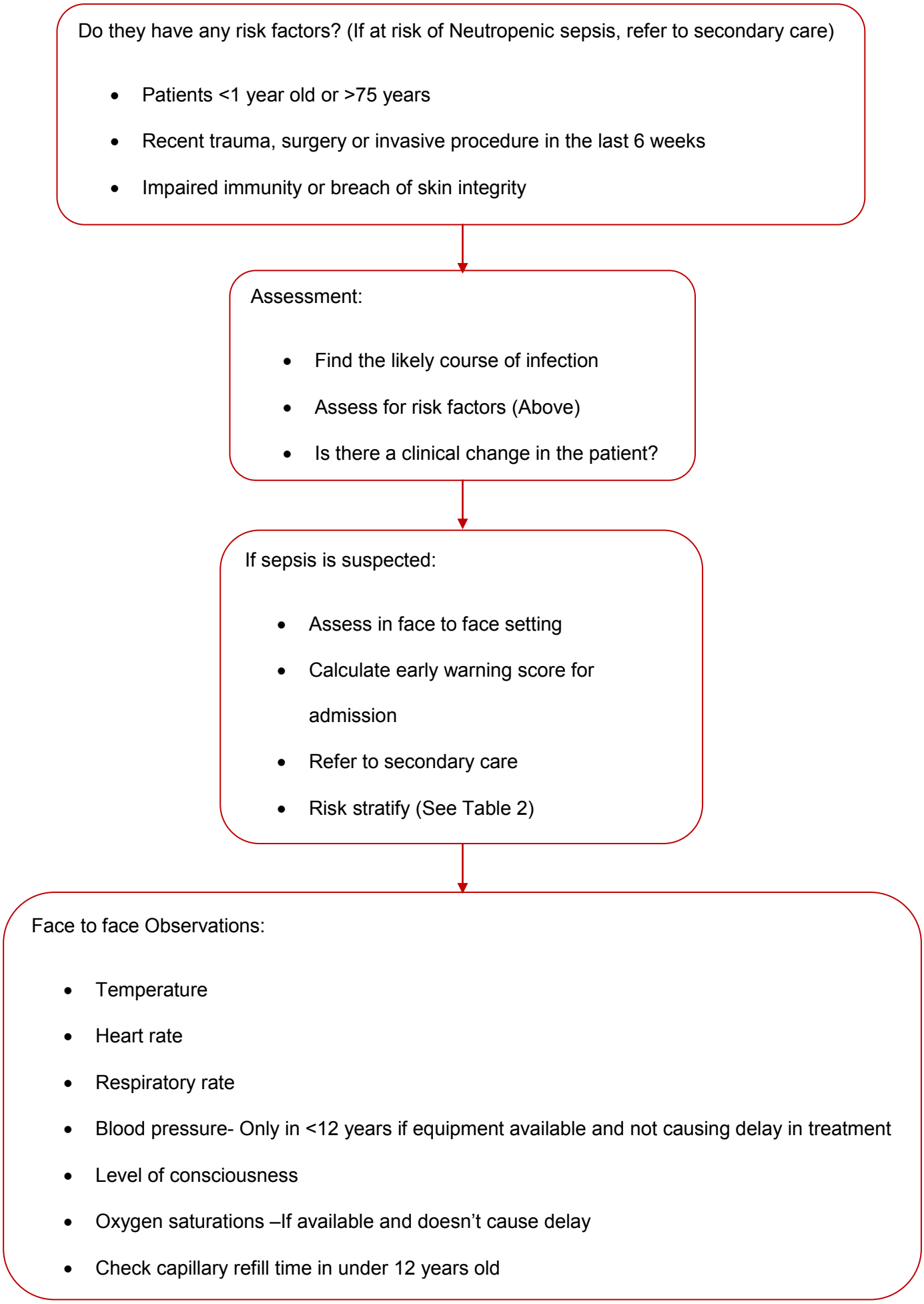

Figure 4-NICE algorithm for identifying sepsis (Taken from 17)

Risk stratification

Table 1-NICE traffic light table for identifying risk of serious illness (Taken from 19)

	RED-High risk	AMBER-Intermediate risk	GREEN-Low risk
Activity	• No response to cues • Looks unwell • Does not wake or stay awake • Weak, high pitched or continuous cry	• Not responding normally to social cues • No smile • Wakes after prolonged stimulation • Decreased activity	• Responds normally to cues • Content/ Smiles • Normal cry • Awakes quickly and stays awake
Circulation and hydration	• Reduced skin turgor	Tachycardia: ➢ >160 bpm aged >12 months ➢ >150 bpm aged 12-24 months ➢ >140 bpm aged 2-5 years • Capillary refill time >3 seconds • Dry mucous membranes • Poor feeding infant • Reduced urine output	• Normal skin and eyes • Moist mucus membranes
Respiratory	• Grunting • Respiratory rate >60 breaths/min • Moderate or severe chest in-drawing	Tachypnoea: ➢ > 50 breaths/min (Aged 6-12 months) ➢ >40 breaths/min (aged >12 months • Oxygen saturation <95% on air • Nasal flaring • Chest crackles	
Colour	• Mottled skin • Cyanosis	• Pallor	Normal colour
Other	• > 38°C (If aged 3 months and above) • Non blanching rash • Bulging fontanelle • Neck stiffness • Status epilepticus • Focal neurological signs • Focal seizures	• >39°C (Aged 3-6 months) • Fever > 5 days • Rigors • Swelling of limb or joint • Non weight bearing limb/ not using an extremity	• No amber or red features

The traffic light table is used following routine assessment to allow for appropriate risk evaluation in feverish children. There are signs in each category included for specific conditions causing serious illness such as neck stiffness when querying meningococcal disease or a bulging fontanelle in bacterial meningitis. These serious illnesses can also cause septicaemia therefore NICE have modified the table for risk stratifying specifically for sepsis in under 5 year olds (Table 2). (14)

Table 2- NICE risk stratification for sepsis in children under 5 (Taken from 14)

	High risk	Moderate to high risk	Low risk
Behaviour	• No response to cues • Looks unwell • Does not wake or stay awake • Weak, high pitched or continuous cry	• Not responding normally to social cues • No smile • Wakes after prolonged stimulation • Decreased activity • Acting differently than normal	• Responds normally to cues • Content/ Smiles • Normal cry • Awakes quickly and stays awake
Heart rate	• < 1 years old: 160 +bpm • 1 to < 3:150+bpm • 3-4 years :140+bpm • Or < 60 bpm at any age	• < 1 years old: 150-159 bpm • 1 to < 3:140-149bpm • 3-4 years :130-139bpm	
Respiratory rate	• < 1 years old: 60 + • 1 to < 3 years: 50+ • 3-4 years : 40+ • Grunting • Apnoea • Oxygen saturation< 90 % on air	• < 1 years old: 50-59 • 1 to < 3 years: 40-49 • 3-4 : 35-39 • Oxygen saturation <91% on air • Nasal flaring	
Other	• Mottled skin • Cyanosis • Non-blanching rash	• Delayed capillary refill (>3) • Reduced urine output • Pallor • Cold hands or feet • Leg pain	• Normal colour
Temperature	• < 36°C • > 38°C (3 months+)	• Aged 3 months + >39 °C	

There are several consistencies in both tables showing five categories with the elements of routine assessment within, to highlight the importance of this assessment in sick children. Here, NICE offers multiple approaches to comment in the different sections. For example, hydration can be monitored via capillary refill time, mucous membranes or urine output. However, NICE also states a routine assessment of specifically heart rate, respiratory rate and capillary refill time must be completed in feverish children as opposed to assessing circulation, hydration and respiratory system.

In summary for high risk patients, the tables show heart rate must be 160+bpm (in age <1 year), 150+bpm (in 1-3 years), 140+bpm (in 3-4 year olds) or less than 60 bpm in any age. To classify as intermediate risk, each age group requires 10 beats per minute less than in high risk.

For high risk according to respiratory rate, measurement must be 60+ breaths per minute (in age <1 year), 50+ (in age 1-3 years) and 40+ (in age 3-4 years). Changes for intermediate risk are 10 breaths per minute less in each age group except for 3-4 year olds which starts from 35 breaths per minute.

A raised capillary refill time can only place one in intermediate classification.

We can see here clinical features are separated by age to differentiate from adult risk stratification. This was proposed by the international panel discussed earlier which NICE have supported. (13)

Causes of Sepsis

Breach of physical barriers in the innate immune system can give rise to infections. Infections are therefore divided by origin and pathogen. These pathogens cause initial infection which may eventually precipitate sepsis and could be a bacteria, virus, fungi or parasite. (4)

The resultant infections leading to sepsis commonly include pneumonia, intra-abdominal infections, urological infection or surgical wound infection. (1) The table below shows the usual pathogens causing these infections.

Table 3- Usual pathogen(s) causing infection (Taken from 2)

Site of origin	Pathogen(s)
Skin	Staphylococcus Aureus Other gram positive cocci
Urinary tract	Escherichia Coli (E. Coli) Other Gram negative rods
Respiratory tract	Streptococcus Pneumoniae
Gall bladder or bowel	Enterococcus Faecalis E.Coli Other gram negative rods Bacteriodes Fragilis
Pelvic organs	Neiseria Gonorrhea Anaerobes

Neonates are particularly at risk of developing sepsis as the mucosal surfaces and immunity are not fully mature at birth reflecting a mortality rate of 10-14%. (4)

Sepsis in the neonatal period and shortly after can be divided into the time period to reflect differences in the causative infectious agents. These are early onset sepsis (EOS) which is birth to 6 days, late onset sepsis (LOS) at 7 to 30 days and then late late onset sepsis (LLOS). (4) EOS pathogens are principally acquired during vaginal birth so the risk depends on the organisms of the mothers' urogenital tract flora. Group B streptococcus (GBS) is present in the flora and thus the leading bacterial cause of EOS. (4)

Prevention and management of sepsis

Sepsis screening

In order to reduce the incidence of sepsis, healthcare systems have screening and prevention methods in place. In 2002, the U.S. introduced guidelines to screen all pregnant women between 35-37 weeks gestation to identify those at risk of transmitting GBS to the newborn. (20) An introduction of penicillin use was made as prophylactic treatment for these women during labour leading to a decline of EOS caused by GBS. (4) However, the U.K. does not provide this due to concern that current screening tests do not sufficiently identify GBS carriers having babies with the disease. (20)

The U.K. does, however, have prevention methods against many paediatric infections to avoid sepsis through immunisations. The routine childhood vaccinations here include the pneumococcal vaccine, meningococcal B, and haemophilus influenza and Meningitis C vaccines as well as others. (21, 22)

Initial management of sepsis

Once stratified, NICE state high risk patients should be sent for emergency resuscitation at secondary care. If this is expected to take longer than one hour, GP and ambulance services must be able to give antibiotics. Children aged up to 17 years old (excluding neonates) with suspected community acquired sepsis should be given Ceftriaxone 80 mg/kg once a day with a maximum dose of 4 grams daily. (23) For intermediate risk patients, there are two options available: a definitive diagnosis can be managed outside hospital if appropriate and an immunocompromised child must be sent for emergency resuscitation at secondary care. (23) Low risk classification can be managed by safety netting: provide information about monitoring symptoms and how to access healthcare if there is progression. (23)

The ‘Sepsis 6 bundle’

Ron Daniels and colleagues at the Good Hope hospital attempted to challenge sepsis in 2005 by designing the ‘sepsis 6 bundle’ for junior doctors to follow. (24). This allowed them to recognise sepsis and initiate management of the condition in an efficient manner. The protocol was tested to show a reduction of 44% to 20% in sepsis death rates when implemented. (24)

Since implementation, the international Surviving Sepsis Campaign in 2010, showed 15,000 cases with delivery of early antibiotics associated with survival. (24) However, early antibiotic delivery was only achieved in 67% of cases. (25) From 2010, recommendation has been changed to delivery of antibiotics within 1 hour of sepsis identification. (15)

The sepsis 6 bundle (26):

1. Administer oxygen to maintain 92% if oxygen saturation is <91% on air for children
2. Obtain blood cultures (before antibiotics) to isolate the causative organism for targeted antibiotic therapy
3. Check lactate levels through arterial blood gases
4. Administer broad spectrum antibiotics within 1 hour (If there is no previous knowledge of the causative agent), then adjust using local guidelines after culture results are back
5. Check urine output to assess hydration
6. Administer intravenous fluids

NICE guidelines for fluid resuscitation (23)

For neonates use crystalloids free from glucose containing sodium between 130-154 mmol/litre with a bolus of 10-20 ml/kg for less than 10 minutes. Children younger than 16 years should be given the same composition but with a bolus of 20ml/kg for less than 10 minutes. Also consider pre-existing conditions which may require smaller volumes of fluid. If

the child is aged 16 + years old, use crystalloids containing sodium between 130-154 mmol/litre with a bolus of 500ml for less than 15 minutes. After completion of the fluid bolus, reassess for improvement. If there is no improvement, give a second bolus and if still no improvement, alert a consultant as they may be in septic shock.

Why is sepsis currently topical?

Statistics/epidemiology

Sepsis is on the rise. This can be seen in the U.K., costing the National Health Service (NHS) £2.5 billion annually. (27) The UK Sepsis Trust estimates there are 150,000 sepsis cases each year in U.K., 25,000 of which are children and resulting in 44,000 deaths per year. (27, 28) In addition, a study conducted by North American Centres for Disease control in 1990 reported a rise in sepsis incidence from 73.6 to 175.9 in 100,000 patients from 1979 to 1989. (1) That is a rise in incidence of 100% in just 10 years. Now looking worldwide, the UK Sepsis Trust concludes there are 18 million cases annually resulting in 8 million deaths, 2 million of which are children. (27)

Despite development in treatments, mortality rates of sepsis remain high with neonatal mortality being 10%-14%. (4) It is also the commonest cause of death in non-coronary adult intensive care units. (7)

Failure of sepsis detection in the community

Since 70% of sepsis cases are acquired in the community, it is important to educate the public about signs and symptoms in order for them to access healthcare quickly. (3) As well as the significance of patients gaining access to a healthcare service, GPs and other out of hospital services such as the NHS Direct service have greater opportunities to recognise sepsis early. (3)

The National Confidential Enquiry into Patient Outcome and Death (NCEPOD) 2015 report 'Just say sepsis' looked at events in GP and saw one third of cases reviewed did not have record of any of the four basic vital signs (temperature, pulse, blood pressure or respiratory rate). (3) This means there is an increasing number of cases where sepsis detection is not being made. Here I refer to an article about a child dying from sepsis in 2014 after NHS Direct failed to classify the patients' case as high risk. (29) Perhaps documenting vital signs

in this child would have increased the likelihood of detection and ultimately avoided death. Unfortunately, this is only one of the many cases we are hearing about in the media regarding sepsis.

In addition, the NCEPOD report states the ‘Sepsis 6 bundle’ is not being implemented in hospitals for majority of cases leading to progression to severe sepsis. (3) This has consequently made sepsis more topical due to the number of patients dying from it. The frustration is understandable here since the protocol was made to be simple in order to improve the number of people using it.

Reason for audit

This audit was undertaken at the Guide Bridge Medical Practice. It looked at the identification of septic children.

The reason for undertaking this audit is due to the increase in sepsis incidence and prevalence in recent years. It is reflected in the media and shown to be an area of popularity in hospitals as sepsis detection is promoted. We have seen this on the wards through 'Sepsis 6 pathway' posters which, as mentioned before, have proven to reduce sepsis prevalence. (24)

However, it is important to note this promotion is in hospitals as opposed to the community. I wanted to observe how well sepsis is being identified and initially managed outside of hospitals as 70% of cases occur in the community. (3) Furthermore, the group of patients chosen were children since they account for a large amount of sepsis sufferers. Children also present more commonly with fevers compared with adults and thus can be an opportunity to improve assessment of, in view of sepsis.

Aims and Objectives

Aim: To improve sepsis detection in general practice.

Objectives:

- Collect data from consultations of children with a temperature > 37.9°C. A raised temperature is used since it commonly presents in septic children and is also the most used observation at the practice.
- Compare assessment of children against NICE guidelines for 'Fever in under 5s' initially and follow this up with NICE guidelines for 'Sepsis recognition' in the same age group.
- Determine if patients have been assessed with heart rate, respiratory rate and capillary refill time.

The following criteria and standards were set from recommendations of NICE guidance (CG160).

Criteria and standards

Table 4 -Criteria and Standards

Criteria	Standard	Evidence Based
Respiratory rate	100%	NICE guidance
Capillary refill time	100%	NICE guidance
Heart rate	100%	NICE guidance

The criteria above collectively comprise a 'routine assessment' for feverish children. The standard is set as 100% as all feverish children should have this assessment. It allows for risk stratification and the consideration of whether appropriate management options were met according to NICE guidance (NG51). Discrepancies identified will allow me to suggest implementation of algorithms for this specific group of patients.

Method

The Guide Bridge Medical Practice has 3650 patients whose consultations are documented via an electronic database called Egton Medication Information services (EMIS). To identify patients with appropriate features of sepsis for this audit, we searched the electronic database under the 'Reed coding' system. Records were obtained from the time period 1.1.16-13.04.17 using the searches:

- Aged 3 months to 5 years old
- Temperature > 37.9°C

Although a high temperature does not wholly rule sepsis in or out, the literature states sepsis in paediatrics requires temperature changes or leukocyte derangement with tachycardia or tachypnoea. This audit therefore looks at the identification of sepsis in those with temperature changes indicating a fever. I looked to see if these patients had a routine assessment of respiratory rate, heart rate and capillary refill time.

At the initial stages of design for the method, I contemplated including respiratory rate > 35 breaths/min and/or heart rate >130beats/min for data collection. This would widen the search for appropriate identification of sepsis and consequent management. Unfortunately, this was expected to yield fewer patient records and in the results later, we can see this is the case as we study the signs recorded.

Instead of including the vital signs as a search in data collection, I set these as criteria to be met for risk stratification by NICE. (14) After categorising patients in corresponding risk groups, I compared their management against their risk. (23)

Audit findings

The method yielded 32 consultations of patients aged 3 months to 5 years old with a temperature greater than 37.9°C in the time period 1.1.16-13.04.17.

A summary of the audit findings are shown in the table below.

Table 5-Summary of findings

Criteria	Compliance	Comments
Complete routine assessment	12.5%	A total of 4 patients had a complete routine assessment.
a. Heart rate (/min)	53%	From the total 32 records, 17 consultations included a measuring of heart rate. This accounted for the largest documented sign in a routine assessment.
b. Respiratory rate	31%	Out of the 32 records obtained, 10 consultations involved recording respiratory rate. Of the instances this was measured, it was never alone but in conjunction with either heart rate or capillary refill time.
c. Capillary refill time	37.5%	12 patient consultations out of 32 documented a capillary refill time.
Behaviour	78%	In 25 consultations, comments were made if the child was alert, happy and acting in their 'usual' behaviour. It is important to note that in nearly every case audited observations on if the child looks well or not were also documented.
Skin changes	84%	In 27 consultations, physicians actively made observations on skin changes such as non blanching rashes and mottled skin in consideration of meningitis and sepsis. These are useful in risk stratification where routine assessment is incomplete.

$$\text{Compliance} = \frac{\text{Number of consultations with documented criteria}}{\text{Total number of consultations from data collection}} \times 100$$

Strengths and weaknesses of method

Strengths

The method used allowed me to search all documented patient records for a thorough data collection. This meant from the documented and coded consultations, I would receive all records meeting my search.

Secondly, I was able to obtain appropriate patient records from a specific search using the 'reed coding' system. This allowed me to filter according to age and clinical feature/s in the boundaries of a specific time period to generate a group of relevant patients to include in the audit. All patients had a temperature > 37.9°C so were relevant for inclusion. I could also remove identifying details such as names, NHS numbers, and the consulting doctor for anonymity.

Overall, the method for data collection was not overly time consuming since it was an electronic search via EMIS.

Weaknesses

A useful search for the method initially would have been 'sepsis', and refine for age and date of consultation. A problem arose here in that I was unable to simply search for 'sepsis' under the coding system since it was unlikely for practitioners to code 'sepsis' for a patient. This may be due to professionals coding clinical features or initial infections as opposed to sepsis. Another reason for this may be that patients weren't considered for sepsis query and thus not coded for. An advantage of this is if included in my data collection, the audit would not have looked at the assessment from all feverish children in identifying sepsis but just those already in consideration. Instead, by searching under a specific temperature range, I was able to analyse against the other vital signs.

Another drawback that I came across was my method relied on professionals coding patients with a temperature specifically > 37.9°C. This meant there may have been additional patients that should have been included for the audit but unable to, due to coding.

In addition, telephone consultations resulted in coding of raised temperature measured by carers. This consultation did not have documentation of signs such as respiratory rate to comment on. Therefore, I have had to carry out separate searches on the patient to check if they had a face to face consultation documented at the time.

Although the data collection itself was not too time consuming, I did have to individually look through records to see if they suited. Then, I studied if criteria were met in each patient. This was a tedious process although an effective and trustworthy one since if we somehow managed to do this electronically, it would not have accounted for human errors such as misspellings in abbreviated vital signs.

Comments on key findings

Complete routine assessment

In total, only 12.5 % of consultations had documented a complete routine assessment of respiratory rate, heart rate and capillary refill time. This is clearly way below the set standard for assessment in feverish children. One reason for this deficit may be physicians performing complete routine assessments only on those feverish children they believed required so, using their clinical judgment from other initial assessments. For example, a heart rate measurement may have been done initially which did not raise any suspicions of serious illness and thus did not follow through with the other two components. This could also explain findings from the breakdown of routine assessment discussed as followed.

Heart rate and respiratory rate

Heart rate recording accounted for the largest documented sign. This may be as the recording is perceived to be weighed more heavily upon for ill health. On the other hand, the criterion of respiratory rate largely defies the set standard. One reason for this is professionals perceiving the sign to be inaccurate since an exact assessment of this may prove to be difficult in the age group. Thus when documented, this sign was never alone but always with either of the other two criteria. Another reason for the lack of respiratory rate measured may be due to assessment of the respiratory system in a different form. This was shown by assessing the use of accessory muscles for breathing difficulties, oxygen saturation, and auscultation of the chest.

Capillary refill time

Results for capillary refill time were not as expected. This measurement can be done quickly with little resistance from the child. It is the simplest component of the routine assessment which is why I expected more documentation of this. Although this simple test is specifically mentioned for NICE routine assessment, circulation and hydration status of the patient can

also be done in other ways, which I believe is the case here. Thus doctors here have assessed for pallor and cyanosis as well as comments on wet nappies for urine output. This may be a more efficient method in time constraints as heart rate can then be measured if it was an option of either or.

Behaviour and skin changes

Although not part of 'routine assessment', NICE guidelines include a category for behaviour and skin changes in their risk stratification for sepsis. Most consultations here were not concerned for sepsis although there is acknowledgment of its possibility, noted in comments of behaviour and skin changes.

Risk stratification

Despite lack of 'complete' routine assessment, I risk stratified these patients according to the NICE guidelines from the documented consultation and resulted in five high risk, four intermediate and twenty three low risk patients. Temperature measurement was the more commonly considered criteria in this risk stratification, particularly in patients between three to six months. After this, in those documented, heart rate, respiratory rate and capillary refill were useful in aiding risk stratification. However, due to the inconsistency in documenting these signs, some risk stratifications relied purely on temperature and comments on behaviour and skin. This produced an inaccurate representation of patients risk for severe illness or sepsis.

Was management appropriate for risk?

With consideration to risk, management of patients were appropriate in most circumstances at the practice. That is, admission for high risk, appropriate management at home (e.g. antibiotics, fluid encouragement etc.) in intermediate risk or reassurance with safety netting for low risk. Three of the patients in total were admitted into hospital; high risk patients should be admitted whilst intermediate patients could be controlled outside of hospital if

possible or admitted. (23) Out of three of the five ‘high risk’ patients from the audit, management was done outside of the hospital setting despite NICE guidance on admission for high risk. There are a couple of comments to make on this. I risk stratified these patients as high according to their heart rate alone; this may have falsely grouped patients. The consulting doctor may have stratified as ‘intermediate’ and perceived their healthcare to be achievable outside hospital. This raises the question, is a ‘high risk’ heart rate enough to stratify the patient as high risk?

Implications of findings to aims

The findings from this audit suggest an inconsistency in routine assessment for feverish children. There is, however, elements of this implemented resulting in 53%, 31% and 37.5% of heart rate, respiratory rate and capillary refill time, respectively, documented. Nonetheless, discrepancies in each category result in insufficient documentation of signs in routine assessment to allow for adequate risk stratification for serious illness or sepsis in the group. This is because an incomplete assessment for feverish children may overlook a heart rate of 160 bpm or a respiratory rate of 50 or even a capillary refill time of 3 seconds. If this is so, it may inaccurately risk stratify the patient and fail to detect sepsis or other severe illnesses.

Previous similar audits in the community

The findings in this audit also support that of the NCEPOD report in 2015 discussed earlier where only a third of patients reviewed for sepsis in GP had vital signs recorded. (3)

One reason for the similarity between results may be explained by the lack of a formal system in place for systematic assessment regarding features of sepsis.

Whilst the NCEPOD report showed a third of patients having vital signs recorded, this audit found only 12.5% of patients having signs recorded for assessment. This may be because they looked at patients that had already been diagnosed with sepsis with admission and audited at GP notes retrospectively while we audited to look at identifying sepsis. Patients were known to have sepsis so retrospective GP notes were more likely to have signs documented since they would probably have more features of ill health and prompt complete assessment. The population in the audits were also different since we looked at children whilst NCEPOD looked at patients aged >16 years old.

Although there are some differences between the audits, they both display a common theme amongst the community; a lack of vital signs recorded.

Areas to improve/Proposal for change

The aim for this audit was to improve sepsis detection in general practice. I have identified a few areas which may attribute to low sepsis detection in the community and thus can be used as targets for improvement.

The first is a lack of consistency in assessment of a feverish child. Some children had their respiratory system assessed by observing their use of accessory muscles or oxygen saturation whilst others by respiratory rate. Hydration in some children was commented on by urine output or by capillary refill time in others. Whilst this may be adequate for risk stratification in sepsis, this particular group of children presented with fever and thus required to have a full routine assessment of heart rate, respiratory rate and capillary refill time before sepsis consideration.

Another point to consider is the inconsistency in actually measuring the signs mentioned. Sometimes heart rate was measured whilst other times respiratory rate. All signs were rarely used in conjunction with each other but seemed it was an option of either/or in most circumstances.

Perhaps if all feverish children were examined with consistent measures, there would be an increase in risk stratification agreeable between multiple professionals. This will consequently follow with adequate management according to risk. I found in some ‘high risk’ patients for this practice, management was achieved outside of secondary care which may be considered insufficient by NICE.

Using both of the NICE guidance mentioned in this audit (CG160, NG51) I have put together an algorithm (Figure 5) combining routine assessment in the age group with risk criteria. Perhaps this will help implement use of a complete routine assessment thus allowing for more valuable risk stratification in children who may have sepsis or other severe illness.

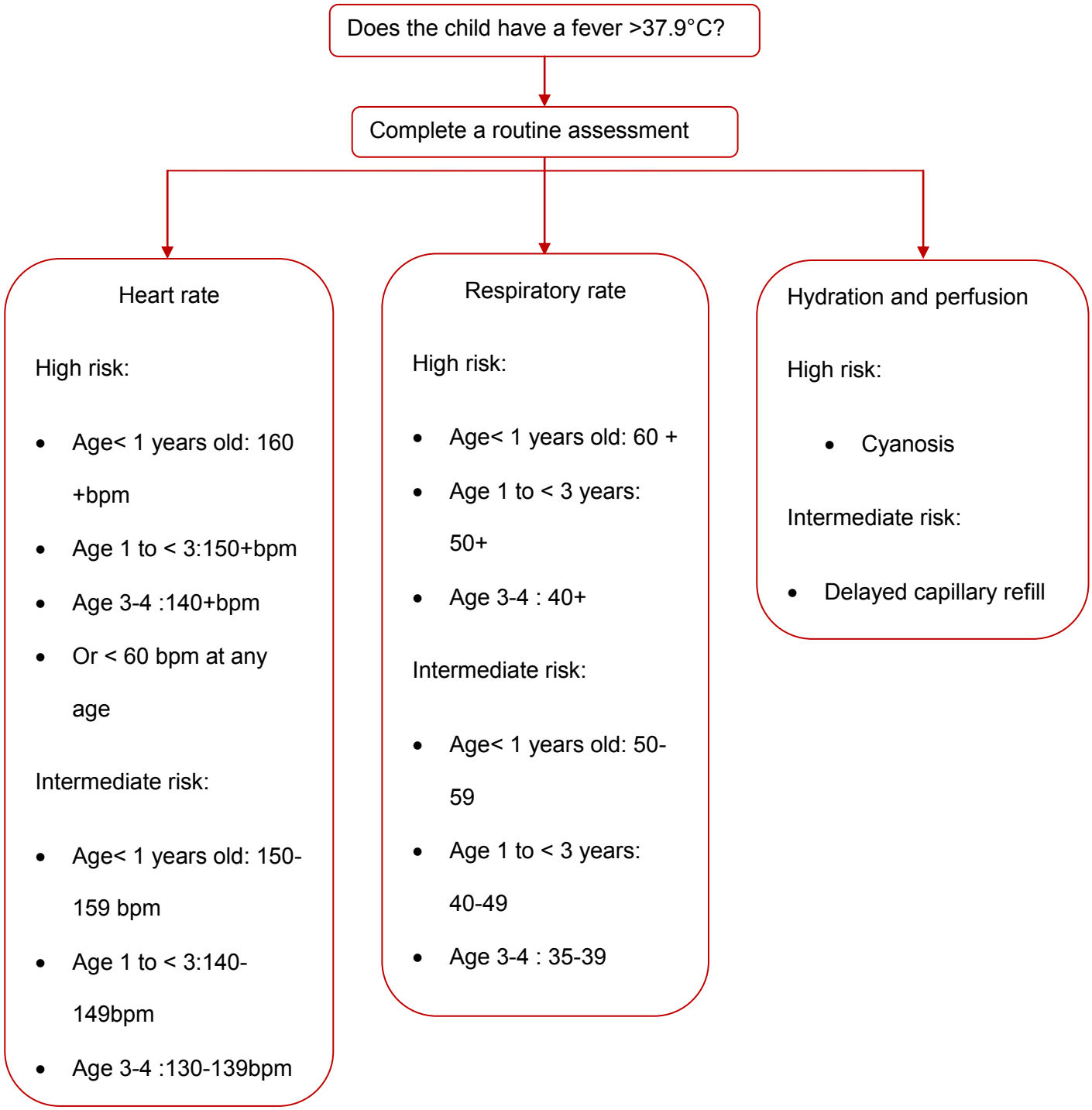

Figure 5- Algorithm for routine assessment in feverish children (Adapted from 17, 18)

Areas of uncertainties, unanswered questions and areas of further work

Although there weren't always a 'complete' routine assessment as depicted by NICE, assessment of each category in their risk stratification tables are still completed in other ways. This begs the question of which method is best for each category.

Are comments on cyanosis, pallor and urine output better at assessing circulation and hydration than capillary refill time? The question is raised since although NICE guidance (CG160- Section 1.2.2.6) explicitly include capillary refill time for routine assessment; it is followed by a 'traffic light' table in the same guidance and a modified table for risk stratification in sepsis (NICE-NG51) in which the circulation and hydration category provides more than one option to comment. Does this indicate a leniency for professionals to use whichever method is appropriate or does one hold a superior value to the other?

The previous comments are also a basis for the next question; can the use of respiratory rate in assessing the respiratory system be substituted by oxygen saturation or observation of accessory muscle use?

Finally, should the routine assessment of a respiratory rate, heart rate and capillary refill time be included in system examinations in this group for consistency? This question is proposed as the discrepancies in compliance between the individual criteria may be accounted for the structure of formal examinations. If we modify this to incorporate the elements of the routine assessment in all system examinations, this may increase the compliance in documenting vital signs in general practice.

Conclusion

An audit was performed at the Guide Bridge Medical practice in aims to improve sepsis detection and consequent management in children. The method used enabled filtering of a specific age group (3 months to 5 years) and temperature (>37.9°C) to initiate data collection. This allowed me to check if a complete routine assessment was documented in these feverish children in the first steps to identify sepsis. Results showed this only occurred in 12.5% of children.

However, NICE guidance also has a risk stratification table which includes multiple methods to assess each category, perhaps an explanation for results. If considering a 'routine assessment' by NICE, one could say there are incomplete examinations of children and consequently insufficient information to adequately risk stratify. On the other hand, if looking at NICE management for septic children under 5, some may comment there is enough evidence to stratify if we appreciate the different methods in assessing specific categories. Therefore, the question raised is should there be only way to comment on a category and if not, should a 'routine assessment' be more lenient to other methods?

In conclusion to this audit and to improve compliance of the routine assessment, I propose the implementation of an algorithm designed for feverish children to adequately risk stratify by incorporating this routine assessment; a re-audit can be performed in 12 months to assess for increase in compliance.

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