

RESEARCH ARTICLE

Open Access



A systematic review of necrotising fasciitis in children from its first description in 1930 to 2018

Arne Schrö¹ , Auré Gerin², Gregory B. Firth³, Kelly S. Hoffmann^{4,5}, Andrew Grieve⁵ and Christina Oetzmann von Sochaczewski^{5,6*} 

Abstract

Background: Necrotising fasciitis is a rapidly progressing soft-tissue infection with a low incidence that carries a relevant risk of morbidity and mortality. Although necrotising fasciitis is often fatal in adults, its case fatality rate seems to be lower in children. A highly variable clinical presentation makes the diagnosis challenging, which often results in misdiagnosis and time-delay to therapy.

Methods: We conducted a protocol-based systematic review to identify specific features of necrotising fasciitis in children aged one month to 17 years. We searched 'PubMed', 'Web of Science' and 'SCOPUS' for relevant literature. Primary outcomes were incidence and case fatality rates in population-based studies, and skin symptoms on presentation. We also assessed signs of systemic illness, causative organisms, predisposing factors, and reconstructive procedures as secondary outcomes.

Results: We included five studies reporting incidence and case fatality rates, two case-control studies, and 298 cases from 195 reports. Incidence rates varied between 0.022 and 0.843 per 100,000 children per year with a case-fatality rate ranging from 0% to 14.3%. The most frequent skin symptoms were erythema (58.7%; 175/298) and swelling (48%; 143/298), whereas all other symptoms occurred in less than 50% of cases. The majority of cases had fever (76.7%; 188/245), but other signs of systemic illness were present in less than half of the cohort. Group-A streptococci accounted for 44.8% (132/298) followed by Gram-negative rods in 29.8% (88/295), while polymicrobial infections occurred in 17.3% (51/295). Extremities were affected in 45.6% (136/298), of which 73.5% (100/136) occurred in the lower extremities. Skin grafts were necessary in 51.6% (84/162) of the pooled cases, while flaps were seldom used (10.5%; 17/162). The vast majority of included reports originate from developed countries.

Conclusions: Clinical suspicion remains the key to diagnose necrotising fasciitis. A combination of swelling, pain, erythema, and a systemic inflammatory response syndrome might indicate necrotising fasciitis. Incidence and case-fatality rates in children are much smaller than in adults, although there seems to be a relevant risk of morbidity indicated by the high percentage of skin grafts. Systematic multi-institutional research efforts are necessary to improve early diagnosis on necrotising fasciitis.

Keywords: Necrotising fasciitis, Children, Systematic review, Incidence rate, Case fatality rate, Predisposing factors, Symptoms

*Correspondence: c.oetzmann@gmail.com

⁵Department of Paediatric Surgery, Chris Hani Baragwanath Academic Hospital, Faculty of Health Sciences, University of the Witwatersrand, 26 Chris Hani Road, ZA-1860 Johannesburg, South Africa

⁶Klinik und Poliklinik für Kinderchirurgie, Universitätsmedizin Mainz, Langenbeckstraße 1, D-55131 Mainz, Germany

Full list of author information is available at the end of the article



Background

Necrotising fasciitis is a rapidly progressing soft-tissue infection, which has historically been linked to penetrating trauma in war times [1]. Paediatric textbooks did not mention necrotising fasciitis before 1973 [2, 3] despite the first case of necrotising fasciitis in a child [4] being reported just six years after the initial description in adults [5]. Selective literature reviews dealing with necrotising fasciitis in childhood usually deduce their recommendations from small case series or reports on adults [6–9]. In them, considerable research effort has been made to analyze necrotising fasciitis on a population based level [10], for specific patient groups at risk for necrotising fasciitis [11], and to facilitate early diagnosis [12–14].

In contrast, the knowledge on paediatric necrotising fasciitis is scarce: One database article identified 334 children with necrotising soft-tissue infections, but focused on treatment, outcome, and a multivariate analysis of independent risk factors for fatal outcomes [15]. The two largest studies reporting on skin signs, risk factors and outcomes include 39 retrospectively assessed [16] and 32 prospectively included cases [17]. The 39 retrospective cases were collected within 30 years [16], whereas the prospective study was conducted within four years, but included 20 neonates [17]. The difference in research on necrotising fasciitis in adults and children may further be emphasised by studies on laboratory parameters that may aid in diagnosis of necrotising fasciitis: While 20 children were investigated in a case-control study [18], a meta-analysis of adult patients included 846 cases from 16 studies [14]. Recently, a systematic review of necrotising fasciitis in children has been published [19], which is hampered by several shortcomings: Limited to articles published in English language after 2010, lack of clearly defined inclusion and exclusion criteria, inclusion of neonates, and cases likely to be Fournier's gangrene due to genital involvement. Therefore, we aimed to identify specific features of necrotising fasciitis in childhood that may aid in early diagnosis and treatment initiation of this devastating disease by means of a systematic review. Furthermore, we aimed to gather information on causative organisms and the necessity of reconstructive procedures following an episode of necrotising fasciitis in children.

Methods

Guidelines and protocol for the systematic review

We developed a Preferred Reporting Items for Systematic Reviews and Meta-Analyses - Protocols [20] compliant protocol (Additional file 1) for the systematic review, and closely followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines [21] during the systematic review.

Literature search strategy

The literature search strategy with its adaptations to the three databases 'PubMed', 'Web of Science' and 'SCOPUS' is laid out in detail in the appendix of the protocol (Additional file 1). A sensitivity-oriented approach combining text elements and Medical Subject Headings was used in all three databases. Literature search was extended towards snowballing the reference lists of all included studies and relevant reviews. We conducted the literature search on the 9th of January 2016 and updated it at the 4th of December 2018.

Types of included studies

Preliminary searches failed to identify prospective studies on signs on presentation. We therefore opted to include retrospective case series and case reports to collect information on these aspects, because information from reports with higher quality were not available. Only population-based data were considered eligible to determine incidence and case-fatality rates.

Inclusion criteria

Inclusion criteria for our systematic review were: Patient age between one month and 17 years. Studies have reported symptoms on presentation separate for each patient or for the whole group if all cases were within the age limit. Studies should indicate whether risk factors were present. Studies have reported on case fatalities. Studies reporting on incidence and case fatality rates on a population-based level must include data within the same age limits as stated above, but do not have to report on signs at presentation or risk factors.

Exclusion criteria

Exclusion criteria for our systematic review were: Studies were narrative reviews. Studies include patient data outside the specified age group that cannot be removed from the reported results. Studies include data on neonates or Fournier's gangrene that cannot be separated from the paediatric data. Studies were reported in languages that could not be adequately translated using Google translator into a language that one of the authors can speak fluently (English, German, French, Dutch/Afrikaans, and Spanish).

Primary and secondary outcomes

Our primary outcomes were: Determine incidence and case-fatality rates of necrotising fasciitis in children from population-based reports and assess skin symptoms on presentation. Our secondary outcomes were: Age-specific case fatality rates, risk factors for necrotising fasciitis, signs of systemic illness due to necrotising fasciitis, microbes causative for necrotising fasciitis and reconstructive procedures following necrotising fasciitis.

Literature selection and data extraction

Two researchers independently assessed the search results and extracted data from the included reports as described in the protocol (Additional file 1). Following de-duplication, titles were independently screened for eligibility followed by reading the abstracts as second and the full-text as a third step. Each step was checked for consistency by another researcher. Differences between the two independent researchers were settled by consensus. If consensus could not be reached, the assessment of a third researcher was decisive. We used a Data extraction sheet (Additional file 2) for the documentation of the results.

Definitions for data acquisition

We defined all skin symptoms which were not explicitly mentioned in a report as absent. This definition was also used for signs of systemic illness not reported. Signs of systemic illness and reconstructive procedures were only included if at least one item was reported in the study, otherwise the respective cells were not included in the analysis. Definitions for the systemic inflammatory response syndrome relied on the international paediatric sepsis consensus conference [22].

Risk factors in the pooled cases

We grouped the underlying conditions or preceding events of the included cases into five distinct risk groups: Varicella, surgery, immunocompromise, trauma, and minor trauma (e.g. an insect bite, a bruise from a fall etc.) and contrasted them with the cases in which necrotising fasciitis occurred without predisposing factors.

Protocol deviations

The study by *Mulla* reports cases of necrotising fasciitis in children caused by group-A streptococci in Florida between August 1996 and August 2000, but did not provide incidence data [23]. We extrapolated incidence data by using census data of Florida in 2000, which counted 3,646,340 persons below 18 years of age [24]. The population data used in the Finnish incidence study [25] had an age limit of 15 years. The neonatal case in the study by *Eneli & Davies* [26] has been excluded and the incidence data were recalculated using population data provided within the report. The report by *Gjessing Jensen & Christensen* [27] was not translated using Google translator as stated in the protocol, because the corresponding author supplied us with an author translation.

Results

Article selection

We identified five studies that reported population-based on incidence and case-fatality rates in 68 cases [23, 25, 26, 28, 29], two case-control studies with 27 cases [30, 31], and another 298 cases from 195 case series and case reports [2–4, 8, 27, 32–221] (Fig. 1).

Incidence rate

Two studies from Canada were prospective: One monitored the whole country [26], whereas the other was limited to Ontario [28]. Another study collected retrospective data for Florida [23] and another relied on the database of a hospital chain in Utah, which claimed to cover 70-85% of all hospital admissions of children in

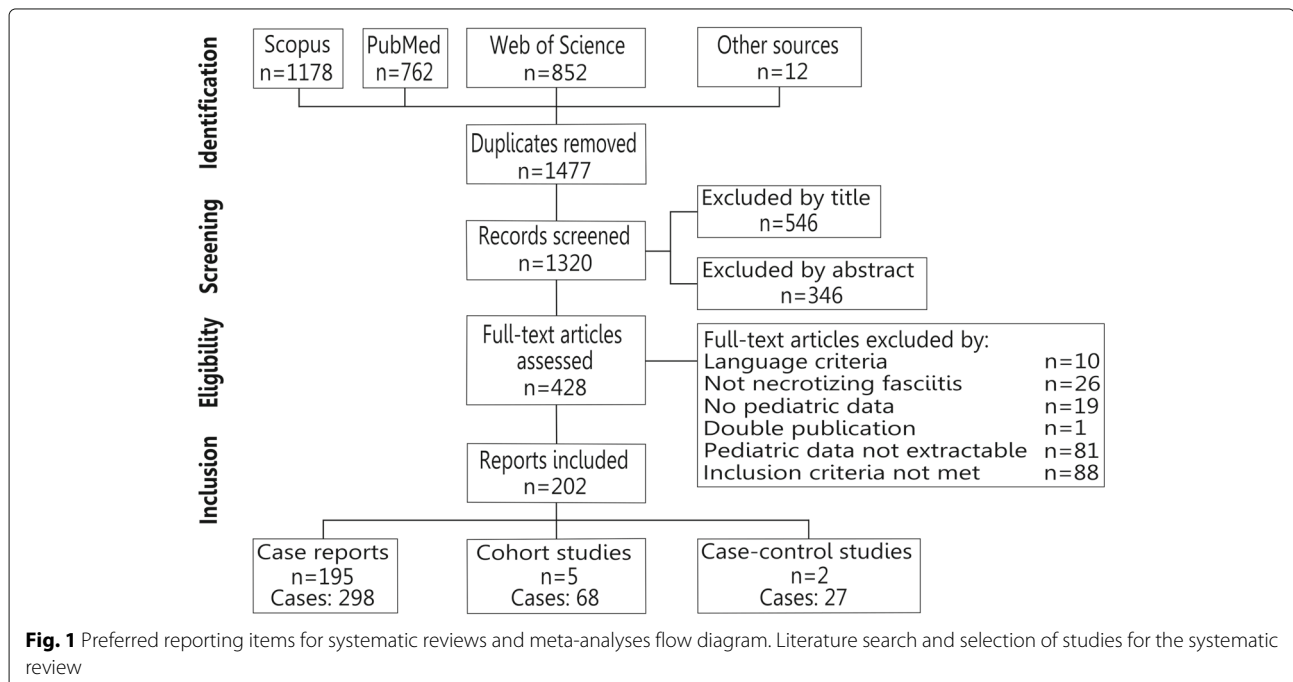


Fig. 1 Preferred reporting items for systematic reviews and meta-analyses flow diagram. Literature search and selection of studies for the systematic review

this state [29]. The last report was based on the data of Finnish university hospitals and the childhood population living in their referral area [25]. Only one study [26] reports incidence data for cases of necrotising fasciitis for both group-A streptococci and non-group-A streptococci, whereas the remaining three studies were limited to necrotising fasciitis caused by group-A streptococci [23, 28, 29]. The incidence rate of necrotising fasciitis varied from 0.843 cases per 100,000 children per year due to group-A streptococci in the Finnish Oulu University Hospital area [25] to 0.022 cases per 100,000 children per year caused by group-A streptococci [23]. Incidence rates of 0.212 cases occurred due to group-A streptococci and 0.0729 cases were caused by all other organisms [26] 0.01 [29] and 0.08 per 100,000 children per year [28] were in between.

Case fatality rate

The case fatality rate differed between 14.3% (1/7) [29], 10% (1/10) [28], and 0% in two reports [(0/3) [23] and (0/13) [25]], but was 2.85% (1/35) in the only study that included cases caused by other germs than group-A streptococci [26].

Properties of the identified case-control studies

The first identified case-control study had a mixed design of retrospectively (5/19) and prospectively (14/19) included cases. It aimed to describe an association between necrotising fasciitis following primary varicella infection and a preceding treatment with ibuprofen [30]. Twenty-nine controls were prospectively identified and had non-necrotising skin infections following primary varicella infection [30]. Therefore, study parameters were collected with the intent to compare baseline variables between two groups [30]. The second case-control study aimed to identify specific features of necrotising fasciitis compared to non-necrotising soft tissue infections [31]. It included cases within 16 years [31], whereas the first study had a duration of 19 months [30].

Age, sex and geographic distribution

The included cases had a similar mean age compared to the case-control studies (Table 1). Distribution of age groups within the pooled cases was similar except for a slight over-representation of school children and a corresponding under-representation of adolescents and infants. Males were predominantly affected in the varicella and ibuprofen case-control study with 74% (14/19) [30], and within the pooled cases (57.4%, 171/298), but not in the second case-control study (3/8 males) [31]. North America accounted for 39.9% (119/298), Asia for 31.9% (95/298), and Europe for 21.1% (63/298) of the included cases. In contrast, South America contributed ten (3.3%), Africa nine (3%), and Oceania only two reports.

Items assessed in the systematic review

The results can be found in Tables 1 and 2. An itemisation for risk factors revealed that there were no obvious differences between them.

Discussion

We aimed to identify features specific to necrotising fasciitis in children by a systematic review. Whereas necrotising fasciitis had been subject to intensive research efforts in adults, knowledge on necrotising fasciitis in children is scarce. We identified four studies reporting population based incidences and case-fatality rates, of which two were prospectively conducted. Moreover, three of them were limited to cases of necrotising fasciitis caused by group-A streptococci and had a narrow geographic focus: Either a Canadian province [28], states within the United States of America [23, 29] or the referral area of Finnish university hospitals [25]. Only one report assessed necrotising fasciitis on a nationwide level [26] and included cases caused by other organisms than group-A streptococci. This might represent an accurate estimation of the burden of disease for an industrialised country. Necrotising fasciitis may be more common in developing countries as indicated by a monocentric Nigerian prospective observational study: It included 32 cases of necrotising fasciitis in childhood within 4 years [17]. Although 20 cases were neonates - leaving 12 children - the report [17] still hints at higher incidences in low-income countries. Moreover, all of these children presented with tissue necrosis [17] indicating an advanced disease [9, 222]. Similarly, ecchymosis and necrosis were found in 72% of cases in the other large case series [16]. In contrast to these late-appearing skin symptoms, pain, erythema, swelling, and - to a lesser extent - splinting were predominant skin symptoms in both case-control studies [30, 31]. The analysis of skin symptoms within the pooled cases did not identify highly frequent lesions: Only erythema had been noted in more than a half of the included cases and swelling in almost a half of the affected cases despite an advanced stage of disease - evidenced by either ecchymosis or necrosis - in 40.6% of the cases. This result may be explained by recall bias: The lack of clinical information that has been present in the patient, but was not documented in the patient's file and thus not included in the published report [223]. Consequently, the more subtle skin symptoms might not be documented in light of the more dramatic changes such as necrosis or discolouration. Recall bias is also likely to have affected the signs of systemic illness within the pooled cases. Signs of systemic illness had similar frequencies among the pooled cases with the exception of fever in 76.6%. This percentage was smaller than the 100% reported in both case-control studies, and the 92% in the largest report on paediatric necrotising fasciitis [16]. Frank et al. [6]

Table 1 Age, risk factors, skin symptoms, and signs of systemic illness in case-control studies and pooled cases

Item	Zerr et al. [30]	Hsieh et al. [31]	Pooled cases [2–4, 8, 27, 32–221]
Age [years] (range)	4.6 (0.5-9.6)	5 (2-13)	5.7 (0.1-17)
Varicella [%] (Number)	100 (19/19)	50 (4/8)	25.9 (77/297)
No risk factor [%] (Number)	0	12.5 (1/8)	22.9 (68/297)
Minor trauma [%] (Number)	0	0	12.5 (37/297)
Immunocompromise [%] (Number)	0	0	11.8 (35/297)
Surgery [%] (Number)	0	12.5 (1/8)	9.4 (28/297)
Trauma [%] (Number)	0	25 (2/8)	8.1 (24/297)
Skin infection [%] (Number)	0	0	6.1 (18/297)
Intramuscular injection [%] (Number)	0	0	1.7 (5/297)
Neuropathy [%] (Number)	0	0	1.4 (4/297)
Diabetes [%] (Number)	0	0	0.4 (1/297)
Erythema [%] (Number)	94.7 (18/19)	87.5 (7/8)	58.7 (175/298)
Swelling [%] (Number)	100 (19/19)	87.5 (7/8)	48 (143/298)
Pain [%] (Number)	100 (19/19)	87.5 (7/8)	33.6 (100/298)
Splinting [%] (Number)	66.7 (12/18)	37.5 (3/8)	3 (9/298)
Tenderness [%] (Number)	0	37.5 (3/8)	25.2 (75/298)
Discolouration [%] (Number)	0	0	32.6 (97/298)
Necrosis [%] (Number)	0	0	32.2 (96/298)
Oedema [%] (Number)	0	0	26.5 (79/298)
Induration [%] (Number)	0	0	14.4 (43/298)
Warmth [%] (Number)	0	0	10.7 (32/298)
Bullae [%] (Number)	0	0	9.1 (27/298)
Discharge [%] (Number)	0	0	8.4 (25/298)
Ecchymosis [%] (Number)	0	0	8.4 (25/298)
Blister [%] (Number)	0	0	6 (18/298)
Crepitus [%] (Number)	0	0	3.7 (11/298)
Fever [%] (Number)	100 (19/19)	Not reported	76.7 (188/245)
Tachycardia [%] (Number)	0	Not reported	40.7 (94/231)
Tachypnea [%] (Number)	0	Not reported	27.7 (64/231)
Hypotension [%] (Number)	26.3 (5/19)	Not reported	29.9 (69/231)
Leukocytosis [%] (Number)	Not reported	Not reported	49.5 (106/214)
Bandemia [%] (Number)	Not reported	Not reported	22.9 (49/214)
Leukopenia [%] (Number)	Not reported	Not reported	17.3 (29/214)
Hypothermia [%] (Number)	0	Not reported	0.8 (2/245)
Bradycardia [%] (Number)	0	Not reported	0.4 (1/231)
Systemic inflammatory response syndrome [%] (Number)	Not reported	Not reported	65.1 (175/269)

suggested that necrotising fasciitis would often go hand in hand with normal white cell counts combined with pronounced bandemia, whereas others associated necrotising fasciitis specifically with increased white cell counts [9]. In both case-control studies, white cell counts did not differ from those in patients diagnosed with cellulitis [30, 31]. Within the pooled cases, 49.5% had leukocytosis, 17.3% leukopenia, and 22.9% bandemia, of which the majority

were found conjointly with leukocytosis. However, leukocyte counts are not part of the paediatric laboratory risk indicator for necrotising fasciitis, developed to differentiate cellulitis from necrotising fasciitis. Only C-reactive protein and sodium levels below 135mmol/L were found to be of relevance [18]. An abnormal leukocyte count or temperature are required to diagnose systemic inflammatory response syndrome, which occurred in 65.1% of the

Table 2 Isolated germs, involved body regions, fatalities, and reconstructive procedures in case-control studies and pooled cases

Item	Zerr et al. [30]	Hsieh et al. [31]	Pooled cases[2–4, 8, 27, 32–221]
Group-A streptococci [%] (Number)	84.2 (16/19)	87.5 (7/8)	44.8 (132/295)
<i>Staphylococcus aureus</i> [%] (Number)	5.3 (1/19)	12.5 (1/8)	18.6 (55/295)
Gramnegative rods combined [%] (Number)	0	0	29.8 (88/295)
<i>Pseudomonas aeruginosa</i> [%] (Number)	0	0	10.2 (30/295)
<i>Escherichia coli</i> [%] (Number)	0	0	7.8 (23/295)
<i>Serratia marcescens</i> [%] (Number)	0	0	1.7 (5/295)
<i>Klebsiella</i> species [%] (Number)	0	0	1.7 (5/295)
Other gramnegative rods [%] (Number)	0	0	8.5 (25/295)
Anaerobe microbes [%] (Number)	0	0	7.1 (21/295)
Other streptococci [%] (Number)	0	0	6.8 (20/295)
Fungi [%] (Number)	0	0	3.4 (10/295)
Other staphylococci [%] (Number)	0	0	3.1 (9/295)
<i>Enterococcus</i> species [%] (Number)	0	0	2.7 (8/295)
Polymicrobial infection [%] (Number)	5.3 (1/19)	0	17.3 (51/295)
Extremities [%] (Number)	63.2 (12/19)	Not reported	45.6 (136/298)
Lower extremity [%] (Number)	Not reported	Not reported	33.9 (100/298)
Upper extremity [%] (Number)	Not reported	Not reported	12.1 (36/298)
Trunk [%] (Number)	21.1 (4/19)	Not reported	32.9 (98/298)
Head [%] (Number)	15.8 (3/19)	Not reported	20.8 (62/298)
Retroperitoneum [%] (Number)	0	Not reported	0.7 (2/298)
Second body region involved [%] (Number)	0	Not reported	16.8 (50/298)
Lower extremity [%] (Number)	0	Not reported	11.1 (33/298)
Trunk [%] (Number)	0	Not reported	3.7 (11/298)
Upper extremity [%] (Number)	0	Not reported	2 (6/298)
More than two body regions involved [%] (Number)	0	Not reported	2.7 (8/298)
Fatalities [%] (Number)	0	0	10.4 (31/295)
Primary closure [%] (Number)	Not reported	Not reported	17.3 (28/162)
Secondary closure [%] (Number)	Not reported	Not reported	20.4 (33/162)
Skin graft [%] (Number)	Not reported	Not reported	51.6 (84/162)
Skin flap [%] (Number)	Not reported	Not reported	10.5 (17/162)

pooled cases. A recent case-control study has shown that fever, tachycardia, and tachypnea might be used to differentiate necrotising fasciitis from abscesses or cellulitis [224]. Thus, a systemic inflammatory response syndrome conjointly with the combination of the most frequent skin symptoms from the case-control studies - swelling, pain, erythema, and probably splinting - might be predictive for necrotising fasciitis. Due to the limitations of the data included in the systematic review, this symptom combination needs to be evaluated for its predictive value before recommendations can be made. Predominant involvement of extremities followed by lesions on trunk and head was a common picture within all included studies. It also is in line with other reports [16] and adult data [11, 225, 226]. This is different concerning polymicrobial

necrotising fasciitis: Previously, polymicrobial infection was commonly reported in paediatric necrotising fasciitis in developed [227] as well as developing countries [16, 17]. Among the pooled cases, in contrast, necrotising fasciitis was usually monomicrobial, which has previously been attributed to necrotising fasciitis following primary varicella infection [30, 31, 222]. Whether the pooled cases provide an accurate estimation of the distribution of mono- and polymicrobial infections needs to be assessed at a larger scale. In particular, Gram-negative rods isolated from wounds may depict a changing spectrum of necrotising fasciitis with a transition of risk factors from primary varicella towards immunocompromised or operated patients. Introduction of varicella vaccination resulted in reduction of the case load of necrotising fasciitis caused

by group-A streptococci [228, 229]. Again, these results have to be validated by large scale studies. The necessary information seem to be available in certain databases as the negative association of both *Streptococcus* spp. and *Staphylococcus* spp. with case fatalities [15] could not have been calculated without knowledge of isolated germs. Case fatality rates have been [225] and still are high in adults [10, 226], but lower or absent in children [16–18, 222, 227, 230]. Higher case fatality rates of 14.3% [29] and 10% [28] have likely been influenced by small sample sizes as the case fatality rate was only 2.85% in the only cohort with more than ten patients [26]. Case fatality rate was 10.4% within the pooled cases and thus higher than in the aforementioned studies. Similarly, the number of cases that required a skin graft was 51.6%, which largely exceeds the previously reported values of skin grafting [17, 230]. There has been considerable variation within the literature: From skin grafts being exceptional [222] to institutions where skin grafting is the regular treatment modality for skin defects following necrotising fasciitis [227]. Probably, necessity for skin grafts was determined by extent of debridement and may thus have influenced the number of skin grafts. Different thresholds for using skin grafts could also play a role. Besides the already mentioned recall bias, several other limitations need to be taken into account for data from case series and case reports. Usually, case reports and series have an exorbitantly high success rate. Either due to preferential reporting of successful results [231] or an over-representation of specialised centres [232], whereas terrible results are scarce and those in between almost non-existent. The extent of this bias is however unclear as an assessment of case series included in Health Technology Assessments of the National Institute of Clinical Excellence of the United Kingdom found no differences in reported outcomes compared to randomised controlled clinical trials on the same subject [233]. Nevertheless, the results from the pooled cases have to be interpreted cautiously and thus require validation by studies of higher quality. Despite the relevance of necrotising fasciitis and its potential grave consequences for the future life of children, these studies are missing. Likely due to the rarity of necrotising fasciitis for the individual institutions, which could be overcome by multiinstitutional collaboration.

Conclusions

A high index of suspicion is necessary to diagnose necrotising fasciitis. A combination of swelling, pain, erythema, and a systemic inflammatory response syndrome might be indicative of early stages of necrotising fasciitis. Incidence and case-fatality rates of necrotising fasciitis in childhood are much smaller than in adults. Nevertheless, necrotising fasciitis seems to carry a relevant risk of morbidity exemplified skin grafting in more than a half of the pooled

cases. A systematic multiinstitutional research effort is necessary to gain meaningful results from future studies to further elucidate necrotising fasciitis in childhood.

Additional files

Additional file 1: Preferred reporting items for systematic reviews and meta-analyses-protocol compliant systematic review protocol. Protocol for the systematic review. (PDF 259 kb)

Additional file 2: Data extraction sheet. Sheet used for data extraction and documentation. (PDF 8 kb)

Additional file 3: Dataset for the pooled cases. Complete database of all cases extracted from the literature and their coding for the respective items. (XLSX 91 kb)

Acknowledgements

We thank Dr. Karsten Gjessing Jensen for providing us with a translated version of his manuscript written in Danish. We acknowledge the capability of the German interlibrary loan service without whose support the retrieval of a dozen non-English reports would have been impossible. We also thank the corresponding authors who provided us with reprints of their articles. Moreover, we are indebted to our patient S. whose gruesome course [221] initiated the present study.

Funding

The systematic review was conducted without funding.

Availability of data and materials

The data used in the present study is appropriately cited. The information on the individual cases is available as Additional file 3.

Authors' contributions

AS, AG, GBF, and CO conceptualised the systematic review and developed the protocol. AS and CO designed the search strategy, which was reviewed by AGr, AS, and CO performed the literature search. AS and CO independently extracted the data. GBF and KSH reviewed the protocol and settled disputes in the data extraction. AS and CO wrote the paper. AG, GBF, KSH, and AGr critically reviewed the manuscript. All authors approved the final version. CO is the guarantor of the work.

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Author details

¹Klinik für Anästhesiologie und Intensivmedizin, Marienkrankenhaus Bergisch-Gladbach, Dr.-Robert-Koch-Straße 18, D-51465 Bergisch-Gladbach, Germany. ²Department of Paediatrics, Chris Hani Baragwanath Academic Hospital, Faculty of Health Sciences, University of the Witwatersrand, 26 Chris Hani Road, ZA-1860 Johannesburg, South Africa. ³Department of Orthopaedic Surgery, Chris Hani Baragwanath Academic Hospital, Faculty of Health Sciences, University of the Witwatersrand, 26 Chris Hani Road, ZA-1860 Johannesburg, South Africa. ⁴Department of Paediatric Surgery, Universitair Medisch Centrum Groningen, Hanzeplein 1, NL-9713 Groningen, The Netherlands. ⁵Department of Paediatric Surgery, Chris Hani Baragwanath Academic Hospital, Faculty of Health Sciences, University of the Witwatersrand, 26 Chris Hani Road, ZA-1860 Johannesburg, South Africa. ⁶Klinik und Poliklinik für Kinderchirurgie, Universitätsmedizin Mainz, Langenbeckstraße 1, D-55131 Mainz, Germany.

Received: 24 April 2018 Accepted: 28 March 2019

Published online: 11 April 2019

References

- Lamb LEM, Sriskandan S, Tan LKK. Bromine, bear-claw scratch fasciotomies, and the eagle effect: management of group a streptococcal necrotizing fasciitis and its association with trauma. *Lancet Infect Dis*. 2015;15(1):109–21. [https://doi.org/10.1016/S1473-3099\(14\)70922-3](https://doi.org/10.1016/S1473-3099(14)70922-3).
- Wilson HD, Haltalin KC. Acute necrotizing fasciitis in childhood. report of 11 cases. *Am J Dis Child*. 1973;125(4):591–5. <https://doi.org/10.1001/archpedi.1973.04160040087018>.
- Hardzog-Britt C, Riley Jr. HD. Acute necrotizing fasciitis in childhood. *J Oklahoma State Med Assoc*. 1995;88(9):392–7.
- Meleney FL. Haemolytic streptococcus gangrene following the administration of scarlet fever antitoxin. *Ann Surg*. 1930;91(2):287–9.
- Meleney FL. Hemolytic streptococcus gangrene. *Arch Surg*. 1924;9(2):317–64. <https://doi.org/10.1001/archsurg.1924.01120080083007>.
- Frank G, Mahoney HM, Eppes SC. Musculoskeletal infections in children. *Pediatr Clin N Am*. 2005;52(4):1083–106. <https://doi.org/10.1016/j.pcl.2005.04.003>.
- Leung AKC, Eneli I, Davies HD. Necrotizing fasciitis in children. *Pediatr Ann*. 2008;37(10):704–10. <https://doi.org/10.3928/00904481-20081001-03>.
- Pandey A, Gangopadhyay A, Upadhyaya VD. Necrotising fasciitis in children and neonates: current concepts. *J Wound Care*. 2008;17(1):5–10. <https://doi.org/10.12968/jowc.2008.17.1.27914>.
- Jamal N, Teach SJ. Necrotizing fasciitis. *Pediatr Emerg Care*. 2011;27(12):1195–202. <https://doi.org/10.1097/PEC.0b013e31823b583c>.
- Audureau E, Hua C, de Prost N, Hemery F, Decousser JW, Bosc R, Lepeule R, Chosidow O, Sbidian E, The Henri Mondor Hospital Necrotizing Fasciitis group. Mortality of necrotising fasciitis: relative influence of individual and hospital-level factors, a nationwide multi-level study, france, 2007–2012. *Br J Dermatol*. 2017. <https://doi.org/10.1111/bjd.15615>.
- Tan JH, Koh BTH, Hong CC, Lim SH, Liang S, Chan GWH, Wang W, Nather A. A comparison of necrotising fasciitis in diabetics and non-diabetics. *Bone Jt J*. 2016;98-B(11):1563–8. <https://doi.org/10.1302/0301-620X.98B11.37526>. <http://bjj.boneandjoint.org.uk/content/98-B/11/1563.full.pdf>.
- Al Alayed K, Tan C, Daneman N. Red flags for necrotizing fasciitis: A case control study. *Int J Infect Dis*. 2015. <https://doi.org/10.1016/j.ijid.2015.04.02>.
- Borschitz T, Schlicht S, Siegel E, Hanke E, von Stebut E. Improvement of a clinical score for necrotizing fasciitis: 'pain out of proportion' and high crp levels aid the diagnosis. *PLOS ONE*. 2015;10(7):1–13. <https://doi.org/10.1371/journal.pone.0132775>.
- Bechar J, Sepehripour S, Hardwicke J, Filobos G. Laboratory risk indicator for necrotising fasciitis (Irinec) score for the assessment of early necrotising fasciitis: a systematic review of the literature. *Ann Royal Coll Surg Eng*. 2017;99(5):341–6. <https://doi.org/10.1308/rcsann.2017.0053>.
- Endorf FW, Garrison MM, Klein MB, Richardson A, Rivara FP. Characteristics, therapies, and outcome of children with necrotizing soft tissue infections. *Pediatr Infect Dis J*. 2012;31(3):221–3. <https://doi.org/10.1097/INF.0b013e3182456f02>.
- Fustes-Morales A, Gutierrez-Castrellon P, Duran-McKinster C, Orozco-Covarrubias L, Tamayo-Sanchez L, Ruiz-Maldonado R. Necrotizing fasciitis: Report of 39 pediatric cases. *Arch Dermatol*. 2002;138(7):893–9. <https://doi.org/10.1001/archderm.138.7.893>.
- Legbo JN, Shehu BB. Necrotising fasciitis: Experience with 32 children. *Ann Trop Pediatr*. 2005;25(3):183–9. <https://doi.org/10.1179/146532805X58111>.
- Putnam LR, Richards MK, Sandvall BK, Hopper RA, Waldhausen JA, Harting MT. Laboratory evaluation for pediatric patients with suspected necrotizing soft tissue infections: A case-control study. *J Pediatr Surg*. 2016;51(6):1022–25. <https://doi.org/10.1016/j.jpedsurg.2016.02.076>.
- Zundel S, Lemaréchal A, Kaiser P, Szavay P. Diagnosis and treatment of pediatric necrotizing fasciitis: A systematic review of the literature. *Eur J Pediatr Surg*. 2017;27(2):127–37. <https://doi.org/10.1055/s-0036-1584531>.
- Moher D, Shamseer L, Clarke M, Ghersi D, Liberati A, Petticrew M, Shekelle P, Stewart LA. Preferred reporting items for systematic review and meta-analysis protocols (prisma-p) 2015 statement. *Syst Rev*. 2015;4(1):1. <https://doi.org/10.1186/2046-4053-4-1>.
- Moher D, Liberati A, Tetzlaff J, Altman DG, Group TP. Preferred reporting items for systematic reviews and meta-analyses: The prisma statement. *PLOS Medicine*. 2009;6(7):1–6. <https://doi.org/10.1371/journal.pmed.1000097>.
- Goldstein B, Giroir B, Randolph A. Members of the International Consensus Conference on Pediatric Sepsis: International pediatric sepsis consensus conference: Definitions for sepsis and organ dysfunction in pediatrics. *Pediatr Crit Care Med*. 2005;6(1):2–8. <https://doi.org/10.1097/01.PCC.0000149131.72248.E6>.
- Mulla ZD. Clinical and epidemiologic features of invasive group a streptococcal infections in children. *Pediatr Int*. 2007;49(3):355–8. <https://doi.org/10.1111/j.1442-200X.2007.02378.x>.
- Demographic Estimating Conference Database. County population by age, race, gender and Hispanic origin, 2000 Census. 2006. Online last accessed: 16 June 2017. <http://edr.state.fl.us/Content/population-demographics/data/web11.xls>.
- Tapiainen T, Launonen S, Renko M, Saxen H, Salo E, Korppi M, Kainulainen L, Heiskanen-Kosma T, Lindholm L, Vuopio J, Huotari T, Rusanen J, Uhari M. Invasive group a streptococcal infections in children: a nationwide survey in finland. *Pediatr Infect Dis J*. 2016;35(2):123–128. <https://doi.org/10.1097/INF.0000000000000945>.
- Eneli I, Davies HD. Epidemiology and outcome of necrotizing fasciitis in children: an active surveillance study of the canadian paediatric surveillance program. *J Pediatr*. 2007;151(1):79–84841. <https://doi.org/10.1016/j.jpeds.2007.02.019>.
- Jensen KG, Kristensen K. Nekrotiserende fasciitis hos børn. *Ugeskr Laeger*. 2009;171(3):147.
- Laupland KB, Davies HD, Low DE, Schwartz B, Green K, McGeer A. Invasive group a streptococcal disease in children and association with varicella-zoster virus infection. ontario group a streptococcal study group. *Pediatrics*. 2000;105(5):e60. <https://doi.org/10.1542/peds.105.5.e60>.
- Stockmann C, Ampofo K, Hersh AL, Blaschke AJ, Kendall BA, Korgenski K, Daly J, Hill HR, Byington CL, Pavia AT. Evolving epidemiologic characteristics of invasive group a streptococcal disease in utah, 2002–2010. *Clin Infect Dis*. 2012;55(4):479–87. <https://doi.org/10.1093/cid/cis422>.
- Zerr DM, Alexander ER, Duchin JS, Koutsky LA, Rubens CE. A case-control study of necrotizing fasciitis during primary varicella. *Pediatrics*. 1999;103(4):783–90. <https://doi.org/10.1542/peds.103.4.783>.
- Hsieh T, Samson LM, Jabbour M, Osmond MH. Necrotizing fasciitis in children in eastern ontario: A case-control study. *CMAJ*. 2000;163(4):393–6.
- Tehrani MA, Webster MHC, Robinson DW, Ledingham IM. Necrotising fasciitis treated by radical excision of the overlying skin. *Br J Plast Surg*. 1976;29(1):74–7. [https://doi.org/10.1016/0007-1226\(76\)90097-7](https://doi.org/10.1016/0007-1226(76)90097-7).
- Andiman WA, Soifer S. Severe streptococcal infection complicating chickenpox. *Clin Pediatr (Phila)*. 1980;19(7):495–7. <https://doi.org/10.1177/000992288001900711>.
- Bomar Jr. WE, Ferlauto JJ, Wells DH. An unusual presentation of a beta-hemolytic group b streptococcal infection. *J Pediatr Surg*. 1980;15(5):683–5. [https://doi.org/10.1016/S0022-3468\(80\)80528-8](https://doi.org/10.1016/S0022-3468(80)80528-8).
- Bush JK, Givner LB, Whitaker SH, Anderson DC, Percy AK. Necrotizing fasciitis of the parapharyngeal space with carotid-artery occlusion and acute hemiplegia. *Pediatrics*. 1984;73(3):343–7.
- Goldberg GN, Hansen RC, Lynch PJ. Necrotizing fasciitis in infancy: report of three cases and review of the literature. *Pediatr Dermatol*. 1984;2(1):55–63. <https://doi.org/10.1111/j.1525-1470.1984.tb00444.x>.
- Woo ML, Patrick WG, Simon MT, French GL. Necrotising fasciitis caused by vibrio vulnificus. *J Clin Pathol*. 1984;37(11):1301–04. <https://doi.org/10.1136/jcp.37.11.1301>.
- Kyong CU, Smith CD, Othersen HB. Necrotizing fasciitis of the abdominal wall as a complication of chickenpox. *Pediatr Infect Dis*. 1985;4(4):420–1. <https://doi.org/10.1097/00006454-198507000-00025>.
- Roos J, De Jong A, Bakker DJ. Een ernstige huid- of weke-deleninfectie is niet altijd gasgangreen. *Ned Tijdschr Geneesk*. 1985;129(15):673–5.
- Stalder JF, Leveque E, Pannier M, Dagorne M, Milpied B. Fasciite nécrosante périorbitaire chez l'enfant. *Ann Dermatol Venerol*. 1986;113(1):75.
- Baillie FB, Linehan IP, Hadfield GJ, Gillett AP, Bailey BN. Infective cutaneous gangrene—urgency in diagnosis and treatment. *Ann Plast Surg*. 1987;19(3):238–46.

42. Collette CJ, Southerland D, Corral C. Necrotizing fasciitis associated with haemophilus influenzae type b. *Am J Dis Child*. 1987;141(11):1146–8. <https://doi.org/10.1001/archpedi.1987.04460110016002>.
43. Cantaloube D, Combemale P, Larroque G, Vaisse D. Les gangrènes cutanées infectieuses du nourrisson. *Rev Stomatol Chir Maxillofac*. 1988;89(3):162–8.
44. Cheng JCY, Leung PC. An unusual case of necrotizing fasciitis of the limb. *J West Pac Orthop Assoc*. 1988;25(2):15–18.
45. Falcone PA, Pricolo VE, Edstrom LE. Necrotizing fasciitis as a complication of chickenpox. *Clin Pediatr (Phila)*. 1988;27(7):339–43. <https://doi.org/10.1177/000992288802700706>.
46. Farrell LD, Karl SR, Davis PK, Bellinger MF, Ballantine TVN. Postoperative necrotizing fasciitis in children. *Pediatrics*. 1988;82(6):874–9.
47. Schwarz G, Sagy M, Barzilay Z. Multifocal necrotizing fasciitis in varicella. *Pediatr Emerg Care*. 1989;5(1):31–3.
48. Goldwag DA, Purcell TB. Necrotizing fasciitis in the pediatric age group: report of a case. *J Emerg Med*. 1990;8(3):299–304. [https://doi.org/10.1016/0736-4679\(90\)90010-S](https://doi.org/10.1016/0736-4679(90)90010-S).
49. Beiroa EN, James ET, Jenas CD, De Paz FB, De Frias EC. Fasciitis necrotizante estreptococcica. *Ann Esp Pediatr*. 1991;35(5):362–4.
50. Pannier M, Bouchot-Hermouet M, Lavergne-Hepner D, Hepner Y, David A, Stalder JF. Fasciite nécrosante péri-orbitaire à streptocoque bêta-hémolytique chez l'enfant. *Ann Chir Plast Esthet*. 1991;36(1):75–8.
51. Rose GE, Howard DJ, Watts MR. Periorbital necrotising fasciitis. *Eye (Lond)*. 1991;5:736–40. <https://doi.org/10.1038/eye.1991.135>.
52. Stone L, Codere F, Ma SA. Streptococcal lid necrosis in previously healthy children. *Can J Ophthalmol*. 1991;26(7):386–90.
53. Boyle MF, Singer J. Necrotizing myositis and toxic strep syndrome in a pediatric patient. *J Emerg Med*. 1992;10(5):577–9. [https://doi.org/10.1016/0736-4679\(92\)90141-F](https://doi.org/10.1016/0736-4679(92)90141-F).
54. Duncan BW, Adzick NS, deLorimier AA, Longaker MT, Ferrell LD, Zoger S, Harrison MR. Necrotizing fasciitis in two children with acute lymphoblastic leukemia. *J Pediatr Surg*. 1992;27(5):668–71. [https://doi.org/10.1016/0022-3468\(92\)90476-N](https://doi.org/10.1016/0022-3468(92)90476-N).
55. Zittergruen M, Grose C. Magnetic resonance imaging for early diagnosis of necrotizing fasciitis. *Pediatr Emerg Care*. 1993;9(1):26–8.
56. Atiyeh BC, Zaatari AM. Necrotizing fasciitis of the upper extremity. *J Emerg Med*. 1994;12(5):611–3. [https://doi.org/10.1016/0736-4679\(94\)90412-X](https://doi.org/10.1016/0736-4679(94)90412-X).
57. Molea G, Bocchini P, Adamo C, Tirone L, Simioli A. Necrotizing fasciitis as a complication of chickenpox - a case report and literature review. *Eur J Plast Surg*. 1994;17(3):151–3. <https://doi.org/10.1007/BF00178682>.
58. Perez Moro A, Cebero Garcia M, Lopez-Herce Cid J, Rubia Fernandez Ldl, Martin Fernandez J, Garcia de Frias E. Fasciitis necrotizante postoperatoria en la infancia. *Acta Pediatr Esp*. 1994;52(7):434–5.
59. Andze G, Pagbe JJ, Douala Mouteng V, Tchokoteu PF, Biwole Sida M, Sandjon JP, Ngonde Sende G, Eteme M, Ekane SN, Bankole R, Edzoa T. Fasciite necrosante post-operatoire chez le nourrisson. a propos d'un cas. *J Chir (Paris)*. 1995;132(2):90–3.
60. Brogan TV, Nizet V, Waldhausen JHT, Rubens CE, Clarke WR. Group a streptococcal necrotizing fasciitis complicating primary varicella: A series of fourteen patients. *Pediatr Infect Dis J*. 1995;14(7):588–93.
61. Misago N, Tanaka T, Takeuchi M, Oka S. Necrotizing fasciitis in association with hyperimmunoglobulin e syndrome. *J Dermatol*. 1995;22(9):673–6. <https://doi.org/10.1111/j.1346-8138.1995.tb03896.x>.
62. Murphy JJ, Granger R, Blair GK, Miller GG, Fraser GC, Magee JF. Necrotizing fasciitis in childhood. *J Pediatr Surg*. 1995;30(8):1131–4. [https://doi.org/10.1016/0022-3468\(95\)90004-7](https://doi.org/10.1016/0022-3468(95)90004-7).
63. Wilson GJ, Talkington DF, Gruber W, Edwards K, Dermody TS. Group a streptococcal necrotizing fasciitis following varicella in children: Case reports and review. *Clin Infect Dis*. 1995;20(5):1333–8. <https://doi.org/10.1093/clinids/20.5.1333>.
64. Barton LL, Jeck DT, Vaidya VU. Necrotizing fasciitis in children: report of two cases and review of the literature. *Arch Pediatr Adolesc Med*. 1996;150(1):105–8. <https://doi.org/10.1001/archpedi.1996.02170260109020>.
65. Estrada B, Stevens DL, Craver RD, Steele RW. A 5-year-old with leg pain. *Infect Med*. 1996;13(7):583–4594597.
66. Hernandez Gonzalez A, Quintero Otero S, Rubio Quinones F, Fernandez O'dogherty S, Ruiz Ruiz C, Marin P, Fregenal J, Pantoja Rosso S. Fasciitis necrotizante: una grave complicacion tras cirugía banal en el niño. *Rev Esp Pediatr*. 1996;52(308):181–4.
67. Mills WJ, Mosca VS, Nizet V. Orthopaedic manifestations of invasive group a streptococcal infections complicating primary varicella. *J Pediatr Orthop*. 1996;16(4):522–8.
68. Navarro Gomez ML, Sanchez Sanchez C, Gomez Campdera JA, Soletto Martin J, De Tomas Palacios E, Moral Torrero R, Hernandez-Sampelayo T. Fasciitis necrotizante en la infancia. presentacion de dos casos. *Rev Esp Pediatr*. 1996;52(311):457–62.
69. Frias Perez MA, Munoz Bonet JL, Vazquez Martinez JL, de la Oliva Senovilla P, Ruza Tarrío F. Un niño con inflamación de tejidos blandos y signos de afectación sistémica. *Ann Esp Pediatr*. 1997;46(6):625–6.
70. Gomes Cordeiro AM, Bousso A, De Cassia I, Fernandes OF, Fernandes JC, Elias FM, Jorge WA, Ejzenberg B, Okay Y. Cervical necrotizing fasciitis in an infant caused by haemophilus non influenzae. *Infection*. 1997;25(6):383–4. <https://doi.org/10.1007/BF01740827>.
71. Mordehai J, Kurzbart E, Cohen Z, Mares AJ. Necrotizing fasciitis and myonecrosis in early childhood: a report of three patients. *Pediatr Surg Int*. 1997;12(7):538–40. <https://doi.org/10.1007/BF01258722>.
72. Poon AH, Terk MR, Colletti PM. The association of primary varicella infection and streptococcal infection of the cutaneous and musculoskeletal system: A case report. *Magn Reson Imaging*. 1997;15(1):131–3. [https://doi.org/10.1016/S0730-725X\(96\)00354-2](https://doi.org/10.1016/S0730-725X(96)00354-2).
73. Sollazzo V, Bertolani G. Su di un raro caso di fascite necrosante. *Ort Traum Oggi*. 1997;17(1):29–31.
74. Sprotte Mira JG, Mocellin M, Pacheco Guedes C, Mercado M, Predebon Vanzo R, Guimaraes Pereira R. Fasciite necrotizante cervical em criança: Relato de caso. *Rev Bras Otorrinolaringol*. 1997;63(1):87–90.
75. Viani RM, Lewis A, Bradley JS. Postoperative group b streptococcal necrotizing fasciitis in a previously healthy child. *Pediatr Infect Dis J*. 1997;16(6):630–1. <https://doi.org/10.1097/00006454-199706000-00019>.
76. Devin B, McCarthy A, Mehran R, Auger C. Necrotizing fasciitis of the retroperitoneum: an unusual presentation of group a streptococcus infection. *Can J Surg*. 1998;41(2):156–60.
77. Donnelly LF, Frush DP, O'Hara SM, Bisset G 3rd. Necrotizing myofasciitis: an atypical cause of "acute abdomen" in an immunocompromised child. *Pediatr Radiol*. 1998;28(2):109–11. <https://doi.org/10.1007/s002470050306>.
78. Lin PC, Lee MJ, Yang W, Hwang CC. Group a streptococcal necrotizing fasciitis after varicella: Report of two cases. *Acta Paed Sin*. 1998;39(6):415–8.
79. Paya K, Hayek BF, Rebhandl W, Pollak A, Horcher E. Retroperitoneal necrotizing fasciitis in a 4-year-old girl. *J Pediatr Surg*. 1998;33(5):778–80. [https://doi.org/10.1016/S0022-3468\(98\)90219-6](https://doi.org/10.1016/S0022-3468(98)90219-6).
80. Polack FP, Coluccio M, Ruttimann R, Gaivronsky RA, Polack NR. Infected stingray injury. *Pediatr Infect Dis J*. 1998;17(4):349–60. <https://doi.org/10.1097/00006454-199804000-00001>.
81. Barapouti FG, Kamel OR, Sampath R. Periorbital necrotising fasciitis in a child. *Eye (Lond)*. 1999;13:676–8. <https://doi.org/10.1038/eye.1999.187>.
82. Chao HC, Kong MS, Lin TY. Diagnosis of necrotizing fasciitis in children. *J Ultrasound Med*. 1999;18(4):277–81. <https://doi.org/10.7863/jum.1999.18.4.277>.
83. Feinerman IL, Tan HK, Roberson DW, Malley R, Kenna MA. Necrotizing fasciitis of the pharynx following adenotonsillectomy. *Int J Pediatr Otorhinolaryngol*. 1999;48(1):1–7. [https://doi.org/10.1016/S0165-5876\(98\)00148-7](https://doi.org/10.1016/S0165-5876(98)00148-7).
84. Lee BE, Robinson JL. The use of technetium-99m - labeled white blood cell scan in the management of a case of group a streptococcus necrotizing fasciitis with polymyositis. *Clin Infect Dis*. 1999;28(1):153–4. <https://doi.org/10.1086/517187>.
85. Sztajn bok J, Lovgren M, Brandileone MCC, Marotto PCF, Talbot JA, Seguro AC. Fatal group a streptococcal toxic shock-like syndrome in a child with varicella: Report of the first well documented case with detection of the genetic sequences that code for exotoxins spe a and b, in são paulo, brazil. *Rev. Inst. Med. Trop. São Paulo*. 1999;41(1):63–5. <https://doi.org/10.1590/S0036-46651999000100011>.
86. Meza A, Gil H. Severe streptococcal infections and toxic shock in children. *Int Pediatr*. 2000;15(4):232–5.
87. Wang SM, Liu CC, Chiou YY, Yang HB, Chen CT. Vibrio vulnificus infection complicated by acute respiratory distress syndrome in a child with nephrotic syndrome. *Pediatr Pulmonol*. 2000;29(5):400–3. [https://doi.org/10.1002/\(SIC\)1099-0496\(200005\)29:5<400::AID-PPUL10>3.0.CO;2-J](https://doi.org/10.1002/(SIC)1099-0496(200005)29:5<400::AID-PPUL10>3.0.CO;2-J).

88. Gonçalves E, Furtado F, Estrada J, Vale MC, Pinto M, Santos M, Moura G, Vasconcelos C. Fasciite necrosante pós varicela. *Acta Med Port.* 2001;14(3):367–70.
89. Johnston DL, Waldhausen JHT, Park JR. Deep soft tissue infections in the neutropenic pediatric oncology patient. *J Pediatr Hematol Oncol.* 2001;23(7):443–7. <https://doi.org/10.1097/00043426-200110000-00010>.
90. Marie-Cardine A, Mallet E, Billiemaz K, Boulesteix J, Bourrillon A, Dechamps C, Duhamel JF, Garnier JM, Gaudelus J, Gendrel D, Jeannot E, Kùpfer I, Labbé A, Lagardère B, Meunier M, Olivier C, Reinert P. Infections cutanées sévères à streptococcus pyogenes chez l'enfant : résultats d'une enquête multicentrique. *Arch Pediatr.* 2001;8(12):1325–32. [https://doi.org/10.1016/S0929-693X\(01\)00653-4](https://doi.org/10.1016/S0929-693X(01)00653-4).
91. Pijnenburg MWH, Cotton MF. Necrotizing fasciitis in an hiv-1-infected infant. *South Afr Med J.* 2001;91(6):500–1.
92. Yanay O, Vaughan DJ, Diab M, Brownstein D, Brogan TV. Retained wooden foreign body in a child's thigh complicated by severe necrotizing fasciitis: A case report and discussion of imaging modalities for early diagnosis. *Pediatr Emerg Care.* 2001;17(5):354–5. <https://doi.org/10.1097/00006565-200110000-00009>.
93. Billiemaz K, Lavocat MP, Teyssier G, Chavrier Y, Allard D, Varlet F. Varicelle compliquée d'une fasciite nécrosante à streptocoque hémolytique du groupe A. *Arch Pediatr.* 2002;9(3):262–5. [https://doi.org/10.1016/S0929-693X\(01\)00762-X](https://doi.org/10.1016/S0929-693X(01)00762-X).
94. Billington M, Goulden N, Tyrrell J, Shield J. Streptococcal fasciitis causing phlegmasia cerulea dolens. *Pediatr Infect Dis J.* 2002;21(2):179.
95. Chakrabarti C, Nehama J, Sood SK. Staphylococcal necrotizing fasciitis and toxic shock syndrome in an adolescent. *Infect Dis Clin Pract.* 2002;11(7):399–402.
96. Chiu S, Chiu C-H, Jaing T-H, Chang K-J, Lin T-Y. Necrotizing fasciitis caused by vibrio vulnificus in a child without known risk factors. *Eur J Pediatr.* 2002;161(8):464–5. <https://doi.org/10.1007/s00431-002-0975-z>.
97. Costet-Fighiera C, Lagier J, Bastiani-Griffet F, Bernard E, Gastaud P. Fasciite nécrosante orbito-palpébrale: Une urgence ophtalmologique à pronostic vital. *J Fr Ophtalmol.* 2002;25(4):375–8.
98. Kobayashi S, Kato T, Nishida S, Buttrago E, Maldini G, Mittal N, Thompson J, Tzakis AG. Necrotizing fasciitis following liver and small intestine transplantation. *Pediatr Transplant.* 2002;6(4):344–7. <https://doi.org/10.1034/j.1399-3046.2002.00210.x>.
99. Newton CL, deLEMOs D, Abramo TJ, Murrey A, Noell C. Cervical necrotizing fasciitis caused by serattia marcescens in a 2 year old. *Pediatr Emerg Care.* 2002;18(6):433–5.
100. Shaaban H, Bayat A, Davenport P, Shah M. Necrotizing fasciitis in an infant with congenital insensitivity to pain syndrome. *Br J Plast Surg.* 2002;55(2):160–3. <https://doi.org/10.1054/bjps.2001.3771>.
101. Yuen JC, Puri SK, Feng Z. Scalp necrotizing fasciitis with osteomyelitis of the skull from aspergillus. *J Craniofac Surg.* 2002;13(6):762–4. <https://doi.org/10.1097/01.SCS.0000026372.14357.D9>.
102. Clark P, Davidson D, Letts M, Lawton L, Jawadi A. Necrotizing fasciitis secondary to chickenpox infection in children. *Can J Surg.* 2003;46(1):9–14.
103. Maheboob SN, Louon AM, Ahmed AH. Necrotizing fasciitis complicated by multiple pneumoceles. *Saudi Med J.* 2003;24(12):1394–6.
104. Miron D, Lev A, Colodner R, Merzel Y. Vibrio vulnificus necrotizing fasciitis of the calf presenting with compartment syndrome. *Pediatr Infect Dis J.* 2003;22(7):666–8. <https://doi.org/10.1097/00006454-200307000-00022>.
105. Rao VPS, Bhat N, Chattopadhyay A, Nagendhar MY. Necrotizing fasciitis with chickenpox. *Indian J Pediatr.* 2003;70(12):961–3. <https://doi.org/10.1007/BF02723820>.
106. Ázyazgan I, DaÇdelen F, Baykan H. Development of necrotizing fasciitis following varicella in two sisters. *Erciyes Tip Dergisi.* 2004;26(1):39–43.
107. Goldschmidt WFM, De Vries HJC, Fijn Van Draat CJ, Van Der Horst CMAM, Sillevs Smitt JH. Necrotiserende fasciitis bij een kind met varicella. *Ned Tijdschr Dermatol Venerol.* 2004;14(5):187–9.
108. Gröger A, Ulrich D, Unglaub F, Pallua N. Varizellenassozierte nekrotisierende fasziiitis beim kind. *Unfallchirurg.* 2004;107(4):325–7. <https://doi.org/10.1007/s00113-004-0759-1>.
109. Kordy FN, Al-Mohsen IZ, Hashem F, Almodovar E, Al Hajjar S, Walsh TJ. Successful treatment of a child with posttraumatic necrotizing fasciitis caused by apophysomyces elegans: Case report and review of literature. *Pediatr Infect Dis J.* 2004;23(9):877–9. <https://doi.org/10.1097/01.inf.0000136870.17071.fid>.
110. Ricalde P, Engroff SL, Jansisanont P, Ord RA. Paediatric necrotizing fasciitis complicating third molar extraction: Report of a case. *Int J Oral Maxillofac Surg.* 2004;33(4):411–4. <https://doi.org/10.1016/j.ijom.2003.08.008>.
111. Ruiz CE, Arango M, Correa AL, López LS, Restrepo A. Fasciitis necrosante por apophysomyces elegans, mohó de la familia mucoraceae, en paciente inmunocompetente. *Biomédica.* 2004;24(3):239–51. <https://doi.org/10.7705/biomedica.v24i3.1270>.
112. Sachdev A, Seth S. Necrotizing fasciitis. *Indian Pediatr.* 2004;41(6):623.
113. Sakran W, Mazzawi S, Merzel Y, Colodner R. Streptococcal necrotizing fasciitis with toxic shock syndrome following cervical adenitis. *Int J Pediatr Otorhinolaryngol.* 2004;68(9):1209–13. <https://doi.org/10.1016/j.ijporl.2004.04.019>.
114. Darbar A, Harris IA, Gosbell IB. Necrotizing infection due to bacillus cereus mimicking gas gangrene following penetrating trauma. *J Orthop Trauma.* 2005;19(5):353–5. <https://doi.org/10.1000140314.00508.c1>.
115. Delibaly A, Bek K, Balbal M, Demircin G, Baysun, Åner A. Necrotizing fasciitis in a child: A rare complication of idiopathic nephrotic syndrome. *Pediatr Nephrol.* 2005;20(1):99–101. <https://doi.org/10.1007/s00467-004-1669-8>.
116. Kurekci AE, Aydin HI, Atay AA, Akar N, Cetan T, Ozcan O, Gokcay E. Familial high factor viii level in a child with necrotizing fasciitis complicating primary varicella infection. *Pediatr Hematol Oncol.* 2005;22(3):219–22. <https://doi.org/10.1080/08880010590921540>.
117. Lo W-T, Cheng S-N, Wang C-C, Chu M-L. Extensive necrotizing fasciitis caused by pseudomonas aeruginosa in a child with acute myeloid leukaemia: Case report and literature review. *Eur J Pediatr.* 2005;164(2):113–4. <https://doi.org/10.1007/s00431-004-1554-2>.
118. Luo C-C, Chin Chao H, Hsun Chiu C. Necrotizing fasciitis: A rare complication of hypospadias surgery in a child. *J Pediatr Surg.* 2005;40(4):29–31. <https://doi.org/10.1016/j.jpedsurg.2005.01.024>.
119. Neo EN, Haritharan T, Thambidorai CR, Suresh V. Pseudomonas necrotizing fasciitis in an immunocompetent infant. *Pediatr Infect Dis J.* 2005;24(10):942–3. <https://doi.org/10.1097/01.inf.0000179548.30554.19>.
120. Abuhammour W, Hasan RA, Rogers D. Necrotizing fasciitis caused by aeromonas hydrophila in an immunocompetent child. *Pediatr Emerg Care.* 2006;22(1):48–51. <https://doi.org/10.1097/01.pec.0000195755.66705.f8>.
121. Cidoncha Escobar E, Urbano Villaescusa J, Marañón Pardo R, Rodríguez Fernández R, Aritmendi Moreno C, Parente Hernández A, Riquelme García O. Fasciitis necrosante por streptococcus pyogenes. *An Pediatr (Barc).* 2006;64(2):167–9. <https://doi.org/10.1157/13084178>.
122. De Decker K, Van Poucke S, Wojciechowski M, Ieven M, Colpaert C, Vogelaers D, Jorens PG. Successful use of posaconazole in a pediatric case of fungal necrotizing fasciitis. *Pediatr Crit Care Med.* 2006;7(5):482–5. <https://doi.org/10.1097/01.PCC.0000235255.68759.05>.
123. Sethi A, Sabherwal A, Puri R, Jain P. Cervicofacial necrotizing fasciitis: An unusual complication of chronic suppurative otitis media. *J Laryngol Otol.* 2006;120(3):. <https://doi.org/10.1017/S0022215110600154X>.
124. Toledo JD, López-Prats J L, Ibiza E, Modesto V, Sanchis R, Vento M. Case 2: An 18-month-old child with necrotic lesions on the limbs. *Acta Paediatr.* 2006;95(11):1506–8. <https://doi.org/10.1080/08035250600732005>.
125. Bhat KG, Shenoy RD, Kamath N. Necrotizing fasciitis in children: Experience in a teaching hospital. *J Pediatr Infect Dis.* 2007;2(4):225–9. <https://doi.org/10.1055/s-0035-1557055>.
126. Binoel-Kologlu M, Yidiz RV, Alper B, Yagmurlu A, Ciftci E, Goekcora IH, Ince E, Emiroglu M, Dindar H. Necrotizing fasciitis in children: diagnostic and therapeutic aspects. *J Pediatr Surg.* 2007;42(11):1892–7. <https://doi.org/10.1016/j.jpedsurg.2007.07.018>.
127. Brady KB, Levin TL. Necrotizing fasciitis in a young girl with atopic eczema. *Clin Pediatr (Phila).* 2007;46(2):181–3. <https://doi.org/10.1177/0009922806293865>.
128. Farrier JN, Kittur MA, Sugar AW. Necrotizing fasciitis of the submandibular region; a complication of odontogenic origin. *Br Dent J.* 2007;202(10):607–9. <https://doi.org/10.1038/bdj.2007.425>.
129. Hon K-IE, Leung E, Burd DA, Leung AKC. Necrotizing fasciitis and gangrene associated with topical herbs in an infant. *Adv Ther.* 2007;24(4):921–5. <https://doi.org/10.1007/BF02849985>.
130. López-Gil Á, Peraza Marín S, Gabrielli G, Burdeinick I, Gabrielli I, Urdaneta C. Zigomicosis cutánea en un paciente de 10 años: Primer

- caso pediátrico en venezuela. revision de la literatura. Arch Venez Puer Ped. 2007;70(1):22–7.
131. Visser DH, Van Den Berg YLF, Van Furth AM, Oomen MW, Schouten-van Meeteren AYN, Pajkrt D, Van Den Bos C, Van Well GTJ. Diagnosis and treatment of cutaneous zygomycosis. *Pediatr Infect Dis J*. 2007;26(12):1165–6. <https://doi.org/10.1097/INF.0b013e318146244b>.
 132. Abass K, Saad H, Abd-Elsayed AA. Necrotizing fasciitis with toxic shock syndrome in a child: a case report and review of literature. *Cases J*. 2008;1(1):228–228. <https://doi.org/10.1186/1757-1626-1-228>.
 133. de Benedictis FM, Osimani P. Necrotizing fasciitis complicating varicella. *Arch Dis Child*. 2008;93(7):619. <https://doi.org/10.1136/adc.2008.141994>.
 134. Demirel N, Bas AY, Zenciroglu A. Can necrotizing fasciitis be the first symptom of hyperimmunoglobulin e syndrome. *Indian J Pediatr*. 2008;75(10):1090. <https://doi.org/10.1007/s12098-008-0171-x>.
 135. Schiavetto RR, Cancian LRL, Haber DM, Maniglia MP, Maniglia CP, Fernandes AM. Fascaíte necrotizante cervical em lactente: Relato de caso. *Arq Int Otorrinolaringol*. 2008;74(4):596–9.
 136. Kamran M, Wachs J, Putterman C. Necrotizing fasciitis in systemic lupus erythematosus. *Semin Arthritis Rheum*. 2008;37(4):236–42. <https://doi.org/10.1016/j.semarthrit.2007.04.005>.
 137. Minodier P, Chaumoitre K, Violet R, Imbert G, Bidete P. Fatal streptococcal toxic shock syndrome in a child with varicella and necrotizing fasciitis of the face. *Eur J Emerg Med*. 2008;15(4):231–3. <https://doi.org/10.1097/MEJ.0b013e3282f08d3d>.
 138. Samsel CB, Bassali RW, Steele Jr. JC, Hultén K. G., Murray DL. Community-acquired methicillin-resistant staphylococcus aureus necrotizing fasciitis in an infant. *Clin Microbiol Newsletter*. 2008;30(22):171–3. <https://doi.org/10.1016/j.clinmicnews.2008.10.003>.
 139. Tsai H-L, Liu C-S, Chang J-W, Wei C-F, Lin J-T, Chin T-W. Severe necrotizing fasciitis of the abdominal wall secondary to colon perforation in a child. *J Chin Med Assoc*. 2008;71(5):259–61. [https://doi.org/10.1016/S1726-4901\(08\)70117-5](https://doi.org/10.1016/S1726-4901(08)70117-5).
 140. Bustos B R, Soto G G, Hickmann O L, Torres B C. Fascitis necrosante palpebral y shock tóxico por streptococcus pyogenes. *Rev Chilena Infectol*. 2009;26(2):152–5. <https://doi.org/10.4067/S0716-10182009000200007>.
 141. Chang Y-C, Lee C-H, Tseng C-L, Chen J-C. Children with lethal streptococcal fasciitis after a minor contusion injury. *Am J Emerg Med*. 2009;27(8):1017–310175. <https://doi.org/10.1016/j.ajem.2008.12.007>.
 142. Eggert J, Bird N, Leitze Z, Peterson M, Van Gils C. Diagnosis and treatment of type ii necrotizing fasciitis in a child presenting with a minor abrasion, edema, and apparent bruising. *Wounds*. 2009;21(3):74–8.
 143. Gerard D, Mariani-Kurkdjian P, Sachs P, Berrebi D, Van-Den-Abbeele T, Dauger S. Facial necrotizing fasciitis in an infant caused by a five toxin-secreting methicillin-susceptible staphylococcus aureus. *Intensive Care Med*. 2009;35(6):1145–6. <https://doi.org/10.1007/s00134-009-1401-z>.
 144. Lee C-Y, Lee H-F, Huang F-L, Chen P-Y. Haemorrhagic bullae associated with a chicken scratch. *Ann Trop Pediatr*. 2009;29(4):309–11. <https://doi.org/10.1179/027249309X12547917869168>.
 145. O'Regan K, O'Mahony E, MacEneaney P, Fitzgerald E, Maher MM. Fulminant limb and retroperitoneal necrotizing fasciitis in a 15-year-old girl with fanconi anaemia. *Pediatr Radiol*. 2009;39(10):1095–97. <https://doi.org/10.1007/s00247-009-1324-4>.
 146. Statham MM, Vohra A, Mehta DK, Baker T, Sarlay R, Rutter MJ. Serratia marcescens causing cervical necrotizing oropharyngitis. *Int J Pediatr Otorhinolaryngol*. 2009;73(3):467–73. <https://doi.org/10.1016/j.ijporl.2008.10.019>.
 147. Tobeia Rua M, Coll Usandizaga F, Garcia Fontecha C, Bartoloma Comas R, Moraga Llop FA. Fascitis necrosante por staphylococcus aureus resistente a la meticilina adquirido en la comunidad productor de leucocidina de panton-valentine. *An Pediatr (Barc)*. 2009;70(4):374–8. <https://doi.org/10.1016/j.anpedi.2008.11.027>.
 148. Uzel A-P, Steinmann G, Bertino R, Korsaga A. Dermohypodermite bactérienne et phlegmon du membre supérieur par morsure de scolopendre : à propos de deux cas. *Chir Main*. 2009;28(5):322–5. <https://doi.org/10.1016/j.main.2009.05.001>.
 149. Al-Shubi FS, Zuker RM, Cole WG. Vacuum-assisted closure as a surgical assistant in life-threatening necrotizing fasciitis in children. *Can J Plast Surg*. 2010;18(4):139–42.
 150. Lehman D, Tseng CW, Eells S, Miller LG, Fan X, Beenhouwer DO, Liu GY. Staphylococcus aureus panton-valentine leukocidin targets muscle tissues in a child with myositis and necrotizing fasciitis. *Clin Infect Dis*. 2010;50(1):69–72. <https://doi.org/10.1086/649217>.
 151. Perbet S, Soummer A, Vinsonneau C, Vandebrouck A, Rackelboom T, Etienne J, Cariou A, Chiche J-D, Mira J-P, Charpentier J. Multifocal community-acquired necrotizing fasciitis caused by a panton-valentine leukocidin-producing methicillin-sensitive staphylococcus aureus. *Infection*. 2010;38(3):223–5. <https://doi.org/10.1007/s15010-010-0002-7>.
 152. Ploier R. Starke schmerzen bei anfangs diskretem lokalbefund: Schmerzen und rötung, später livide verfärbung mit nekrose im wadenbereich. *Monatsschr Kinderheilkd*. 2010;158(3):210–3. <https://doi.org/10.1007/s00112-009-2082-y>.
 153. Purkait R, Samanta T, Basu B, Ganguly S. Unusual associations of necrotizing fasciitis: A case series report from a tertiary care hospital. *Indian J Dermatol*. 2010;55(4):399–401. <https://doi.org/10.4103/0019-5154.74571>.
 154. Robinson AB, Dewitt EM, Schanberg LE, Moody MA. Necrotizing fasciitis caused by haemophilus influenzae type e in a 17-year-old girl with systemic lupus erythematosus. *J Clin Rheumatol*. 2010;16(1):49–50. <https://doi.org/10.1097/RHU.0b013e3181c7e095>.
 155. Roy M, Ahmed S, Pal J, Biswas S. Community acquired methicillin resistant staphylococcus aureus: a rare presentation. *Indian J Pediatr*. 2010;77(11):1332–4. <https://doi.org/10.1007/s12098-010-0171-5>.
 156. Sablier F, Slaouti T, Drèze P-A, El Fouly PE, Allemeersch D, Van Melderen L, Smeesters PR. Nosocomial transmission of necrotizing fasciitis. *Lancet*. 2010;375(9719):1052. [https://doi.org/10.1016/S0140-6736\(10\)60052-9](https://doi.org/10.1016/S0140-6736(10)60052-9).
 157. Scheepers MA, Keel S, Michaelides M. Bilateral necrotizing fasciitis of the ocular adnexa secondary to pseudomonas aeruginosa septicaemia in a hiv-positive child. *Orbit*. 2010;29(1):63–4. <https://doi.org/10.3109/01676830903258847>.
 158. Senaran H, Karalezli N, Ogun TC. A very uncommon complication following vaccination: Necrotizing fasciitis and myonecrosis: Case report. *Turkiye Klinikleri J Med Sci*. 2010;30(1):384–6. <https://doi.org/10.5336/medsci.2008-8341>.
 159. Benatiya Andaloussi I, Abdellaoui M, Bhallil S, Tahri H. Fascaíte nécrósante orbito-palpébrale, compliquant une pansinusite chez un patiente diabétique. *Pan Afr Med J*. 2011;10:10. <https://doi.org/10.11604/pamj.2011.10.10.1096>.
 160. Delasobera BE, Place R, Howell J, Davis JE. Serious infectious complications related to extremity cast/splint placement in children. *J Emerg Med*. 2011;41(1):47–50. <https://doi.org/10.1016/j.jemermed.2010.05.031>.
 161. Fernandes C, Dâmaso C, Duarte R, Cardoso DS, Casella P. Fascaíte necrotizante pós-apendicite aguda. *Acta Med Port*. 2011;24(SUPPL.3):621–6.
 162. Gupta AK, Bonajmah AA. Varicella-related musculoskeletal complications in children. *J Pediatr Orthop B*. 2011;20(4):264–9. <https://doi.org/10.1097/BPB.0b013e328345348f>.
 163. Kuzdan C, Soysal A, Altinkanat G, Aksu B, Soyletir G, Bakir M. Recurrent fatal necrotizing fasciitis due to streptococcus pyogenes in a child with hereditary sensory and autonomic neuropathy type iv. *Jpn J Infect Dis*. 2011;64(2):147–9.
 164. Manzani Baldi JR, Rodríguez G. Fascitis necrosante bilateral de diseminación hematogena por staphylococcus aureus: Caso pediátrico. *Cir Plast Iberolatinoam*. 2011;37(2):171–5. <https://doi.org/10.4321/s0376-78922011000200011>.
 165. Shirley R, Mackey S, Meagher P. Necrotizing fasciitis: a sequelae of varicella zoster infection. *J Plast Reconstr Aesthet Surg*. 2011;64(1):123–7. <https://doi.org/10.1016/j.bjps.2010.03.031>.
 166. Singh DV, Thomas S, Nair PP, Cyriac S, Tripathi GM. Necrotizing fasciitis of face - our experience in its management. *BMJ Case Reports*. 2011. <https://doi.org/10.1136/bcr.07.2011.4453>.
 167. Ahmed S, Ali SR, Samani ZA. Pseudomonas necrotizing fasciitis in an otherwise healthy infant. *Case Rep Infect Dis*. 2012;517135. <https://doi.org/10.1155/2012/517135>.
 168. Chung V, Scott A. Cervical necrotizing fasciitis in children under two years of age. *Int J Pediatr Otorhinolaryngol*. 2012;76(12):1857–60. <https://doi.org/10.1016/j.ijporl.2012.09.012>.
 169. Ferreira DDC, Frota ACC, Cavalcante FS, Abad ED, Dos Santos KRN. Necrotizing fasciitis secondary to community pneumonia by panton-valentine leukocidin-positive methicillin-resistant staphylococcus aureus. *Am J Respir Crit Car Med*. 2012;186(2):202–3. <https://doi.org/10.1164/ajccm.186.2.202>.

170. King E, Chun R, Sulman C. Pediatric cervicofacial necrotizing fasciitis: A case report and review of a 10-year national pediatric database. *Arch Otolaryngol Head Neck Surg.* 2012;138(4):372–5. <https://doi.org/10.1001/archoto.2012.119>.
171. Li F, Xia J. Necrotizing fasciitis following varicella in a child. *Chin Med J.* 2012;125(5):951–3. <https://doi.org/10.3760/cma.j.issn.0366-6999.2012.05.040>.
172. Muggeo P, Arcamone G, Rizzo A, Santoro N. Necrotizing fasciitis of the lower limbs. *Pediatr Rep.* 2012;4(1):4. <https://doi.org/10.4081/pr.2012.e4>.
173. Prelog T, Jereb M, Čuček I, Jazbec J. Necrotizing fasciitis caused by *Serratia marcescens* after venous access port implantation in a child with acute lymphoblastic leukemia. *J Pediatr Hematol Oncol.* 2012;34(6):246–8. <https://doi.org/10.1097/MPH.0b013e318253f047>.
174. Seigel JK, Stadler ME, Lombrano JL, Almony JS, Couch ME, Belhorn TH. *Chromobacterium violaceum* necrotizing fasciitis: A case report and review of the literature. *ENT J.* 2012;91(11):479–83.
175. Yeilding RH, O'Day DM, Li C, Alexander PT, Mawn LA. Periorbital infections after dermabond closure of traumatic lacerations in three children. *J AAPOS.* 2012;16(2):168–72. <https://doi.org/10.1016/j.jaapos.2011.11.014>.
176. Bagri N, Saha A, Dubey NK, Rai A, Bhattacharya S. Skin grafting for necrotizing fasciitis in a child with nephrotic syndrome. *Iran J Kidney Dis.* 2013;7(6):496–8.
177. Belmir R, Fejjal N, Khales A, Achbouk H, El Omari M, El Mazouz S, Gharib N, Abbasi A, Belmahi A. Fasciite nécrosante compliquant un bandage de dujarié: À propos d'une observation. *Ann Chir Plast Esthet.* 2013;58(4):362–6. <https://doi.org/10.1016/j.anplas.2010.12.002>.
178. Ho C, Israni M, Johnson J. Visual diagnosis: 10-year-old girl with fever and altered mental status. *Pediatr Rev.* 2013;34(10):474–7. <https://doi.org/10.1542/pir.34.10.474>.
179. Jing-Chun Z, Chun-Jing X, Shi K, Jia-Ao Y. Severe multiple necrotizing fasciitis complicated by abdominal compartment syndrome in an infant. *Iran J Pediatr.* 2013;23(5):601–3.
180. Ocana Y, Ulloa-Gutiérrez R, Yock-Corales A. Fatal necrotizing fasciitis in a child following a blunt chest trauma. *Case Rep Pediatr.* 2013;3:73712. <https://doi.org/10.1155/2013/373712>.
181. Rosenbaum A, Papaliadis A, Alley M, Lisella J, Flaherty M. *Bacillus cereus* fasciitis: a unique pathogen and clinically challenging sequela of inoculation. *Am J Orthop (Belle Mead NJ).* 2013;42(1):37–9.
182. Tancevski A, Bono K, Willis L, Klingele K. Necrotizing fasciitis in a pediatric orthopedic population. *Orthopedics.* 2013;36(6):741–5. <https://doi.org/10.3928/01477447-20130523-18>.
183. Van Crombrugge L, Van Hoecke H, Roche N, Dhooge I. A rare case of necrotizing fasciitis of the external ear. *Int J Pediatr Otorhinolaryngol.* 2013;8(2):44–6. <https://doi.org/10.1016/j.pedex.2013.01.004>.
184. Bhasin A, Tolan RW. Resurgence of methicillin-sensitive staphylococcus aureus in the community-associated, methicillin-resistant staphylococcus aureus era: Four novel cases and review. *Infect Dis Clin Pract.* 2014;22(1):1–7. <https://doi.org/10.1097/IPC.0b013e31828f4ff8>.
185. Hernandez CRI, Herrera CB, Medina PL, Soto BOG. La fasciitis necrosante en niños: Ana complicación indeseable. *Rev Mex Pediatr.* 2014;81(1):15–7.
186. Karakus SC, Kilincaslan H, Koku N, Parmaksiz ME. Necrotizing fasciitis following soave procedure in hirsprung disease. *Eur J Pediatr Surg.* 2014;24(2):190–2. <https://doi.org/10.1055/s-0032-1330849>.
187. Kwak BO, Lee MJ, Park HW, Song MK, Chung S, Kim KS. Necrotizing fasciitis and streptococcal toxic shock syndrome secondary to varicella in a healthy child. *Korean J Pediatr.* 2014;57(12):538–41. <https://doi.org/10.3345/kjp.2014.57.12.538>.
188. Lithgow A, Duke T, Steer A, Smeesters PR. Severe group A streptococcal infections in a paediatric intensive care unit. *J Paediatr Child Health.* 2014;50(9):687–92. <https://doi.org/10.1111/jpc.12601>.
189. Alsaif MA, Robinson JL. *Escherichia coli* necrotizing fasciitis in hirsprung's disease. *J Pediatr Surg Case Reports.* 2015;3(4):174–5. <https://doi.org/10.1016/j.jpesc.2015.03.002>.
190. Boo YJ, Nam MH, Lee EH, Lee KC. Cyclic neutropenia with a novel gene mutation presenting with a necrotizing soft tissue infection and severe sepsis: case report. *BMC Pediatr.* 2015;15:34. <https://doi.org/10.1186/s12887-015-0352-5>.
191. Cutillas-Ruiz R, Mateos-Segura C, Montoliu-Peco C, Covaci-Covaci O, Pérez De La Fuente T. Fasciitis necrosante en un niño. evolución y tratamiento. *Rehabilitación.* 2015;49(4):256–9. <https://doi.org/10.1016/j.rh.2015.05.002>.
192. Goldberg BE, Sulman CG, Chusid MJ. Group a beta streptococcal infections in children after oral or dental trauma: A case series of 5 patients. *ENT J.* 2015;94(1):e1.
193. Haseeb AA, Okasha S, Elbarawi A. Multifocal necrotizing fasciitis following hirsprung's disease surgery away from the surgical wound site. *Ann Pediatr Surg.* 2015;11(2):159–61. <https://doi.org/10.1097/01.XPS.0000462930.03634.9f>.
194. Hearn P, Miliya T, Hor S, Sar V, Turner P. Necrotizing fasciitis complicating snakebite in cambodia. *IDCases.* 2015;2(3):86–7. <https://doi.org/10.1016/j.idcr.2015.09.001>.
195. Jain J, Thatte S, Singhai P. Periorbital varicella gangrenosa: A rare complication of chicken pox. *Oman J Ophthalmol.* 2015;8(1):64–6. <https://doi.org/10.4103/0974-620X.149874>.
196. Jauregui JJ, Bor N, Thakral R, Standard SC, Paley D, Herzenberg JE. Life-and limb-threatening infections following the use of an external fixator. *Bone Jt J.* 2015;97-B(9):1296–300. <https://doi.org/10.1302/0301-620X.97B9.35626>.
197. Khurana S, Pushker N, Naik SS, Changole MD, Ghonsikar V, Bajaj M. Periorbital necrotizing fasciitis in infants: Presentation and management of six cases. *Trop Doct.* 2015;45(3):188–93. <https://doi.org/10.1177/0049475515575671>.
198. Kumar M, Meeks A, Kearn L. Necrotizing fasciitis of the chest wall. report of pediatric cases. *Pediatr Emerg Care.* 2015;31(9):656–60. <https://doi.org/10.1097/PEC.0000000000000316>.
199. Mugambi MS, Theron A, Cox S, Pillay K, Millar AJW, Numanoglu A. Disseminated mucormycosis and necrotizing fasciitis in immune-compromised patients: Two case reports. *Ann Pediatr Surg.* 2015;11(1):35–9. <https://doi.org/10.1097/01.XPS.0000459980.60002.27>.
200. Song C, Hamilton R, Song C, Kong TY, Lo S. Enabling the diagnosis of necrotizing fasciitis without associated skin changes in a paediatric patient with acute lymphoblastic leukaemia: The Irinec score. *J Plast Reconstr Aesthet Surg.* 2015;68(1):23–4. <https://doi.org/10.1016/j.bjps.2014.08.044>.
201. Srinivas SM, Patil AT, Shankar G, Lakshminantha KM, Govindraj M. Necrotizing fasciitis associated with systemic lupus erythematosus in a child. *Indian Dermatol Online J.* 2015;6(6):441–2. <https://doi.org/10.4103/2229-5178.169737>.
202. Stone LA, Harshbarger RJ 3rd. Orbital necrotizing fasciitis and osteomyelitis caused by *arcanobacterium haemolyticum*: a case report. *OPhthol Plast Reconstr Surg.* 2015;31(2):31–3. <https://doi.org/10.1097/IOP.0000000000000057>.
203. Sturgeon JP, Segal L, Verma A. Going out on a limb. do not delay the diagnosis of necrotizing fasciitis in varicella infection. *Pediatr Emerg Care.* 2015;31(7):503–7. <https://doi.org/10.1097/PEC.0000000000000255>.
204. Szabo L, Szegedi I, Kiss C, Szikszay E, Remenyik E, Csizy I, Juhasz I. Excessive pediatric fasciitis necrotisans due to *pseudomonas aeruginosa* infection successfully treated with negative pressure wound therapy. *Dermatol Ther.* 2015;28(5):300–2. <https://doi.org/10.1111/dth.12252>.
205. Zaman K, Kaur H, Rudramurthy SM, Singh M, Parashar A, Chakrabarti A. Cutaneous mucormycosis of scalp and eyelids in a child with type i diabetes mellitus. *Indian J Dermatol Venerol Leprol.* 2015;81(3):275–8. <https://doi.org/10.4103/0378-6323.152740>.
206. Lin Y-S, Hung M-H, Chen C-C, Huang K-F, Ko W-C, Tang H-J. Tigecycline salvage therapy for necrotizing fasciitis caused by *vibrio vulnificus*: Case report in a child. *J Microbiol Immunol Infect.* 2016;49(1):138–41. <https://doi.org/10.1016/j.jmii.2013.04.008>.
207. Waldeck K, Daniels R, Watson M, Shahbaz L. Multifocal necrotizing fasciitis due to group a strep presenting with otalgia in a pediatric patient. *Soc Crit Care Med.* 2016;44(12, Suppl). <https://doi.org/10.1097/01.ccm.00000510441.27310.11>.
208. Lemaréchal A, Zundel S, Szavay P. Pediatric necrotizing fasciitis: Restitutio ad integrum after early diagnosis and aggressive surgical treatment. *Eur J Pediatr Surg Rep.* 2016;4:34–6. <https://doi.org/10.1055/s-0036-1594307>.
209. Tyler K, Patterson A, Hebra A. Necrotizing fasciitis in a healthy pediatric patient caused by enterobacter cloacae and *Serratia marcescens*: A discussion of diagnosis and management. *Am Surg.* 2016;82:e292–3.
210. Al-Hashmi SN, Sethu A, Al-Busaidi SS, Nelofer M. Immediate nasal reconstruction with a forehead flap in a 2.5-year-old girl following *pseudomonas aeruginosa*-induced necrotizing fasciitis – a case report and literature review. *JPRAS Open.* 2017;14:16–22. <https://doi.org/10.1016/j.jptra.2017.08.002>.

211. Pfeifle VA, Gros SJ, Holland-Cunz S, Kämpfen A. Necrotizing fasciitis in children due to minor lesions. *J Pediatr Surg Case Rep*. 2017;25:52–5. <https://doi.org/10.1016/j.epsc.2017.08.005>.
212. Emami SM, Mir mohamadi P, Jafarzadeh Esfehiani R. Skin and soft tissue infection as a complication of varicella infection ended up in using intravenous immunoglobulin instead of surgical debridement: A case report and short review of literature. *Arch Clin Infect Dis*. 2017;12(4). <https://doi.org/10.5812/archcid.66108>.
213. Ballesteros-Betancourt JR, García-Tarriño R, Ríos-Guillermo J, Rodríguez-Roiz JM, Camacho P, Zumbado-Dijeres A, Domingo-Trepal A, Llusá-Pérez M, Combalia-Aleu A, García-Ramiro S, Soriano-Viladomiu A. Infecciones necrosantes de partes blandas atendidas en un servicio de urgencias de tercer nivel: evolución y correlación con la escala laboratory risk indicator for necrotizing fasciitis (Irinec). *Rev Esp Cir Ortop Traumatol*. 2017;61(4):265–72. <https://doi.org/10.1016/j.recot.2017.04.003>.
214. Kauffman JD, O'Brien M, Snyder CW, Rottgers SA, Rideout DA, Chandler NM. Acute appendicitis complicated by necrotizing fasciitis in a teenager. *J Pediatr Surg Case Rep*. 2018;37:77–82. <https://doi.org/10.1016/j.epsc.2018.07.018>.
215. Fernández-Ibieta M. Necrotic lesions following elective urological surgery in an infant. *Surg J*. 2018;4:e133–5. <https://doi.org/10.1055/s-0038-1668112>.
216. Olsson L, Vuity D, McAllister P, Ansell M. Periorbital necrotising soft tissue infection in a 12-year-old patient. *Scot Med J*. 2018;63:87–90. <https://doi.org/10.1177/0036933018776830>.
217. Proia AD. Periocular necrotizing fasciitis in an infant. *Surv Ophthalmol*. 2018;63(2):251–6. <https://doi.org/10.1016/j.survophthal.2017.03.002>.
218. Bloch D, Gonzalez MD, Haight A, Abramowsky C, Yildirim I. Necrotizing fasciitis caused by mucor indicus in a pediatric bone marrow transplant recipient. *Pediatr Transplant*. 2018;22:13294. <https://doi.org/10.1111/ptr.13294>.
219. Darmasseelane K, Banks T, Rjabova T. Necrotising fasciitis as a complication of primary varicella infection in an immunocompetent child. *BMJ Case Reports*. 2018. <https://doi.org/10.1136/bcr-2018-225018>.
220. Setiawati W, Satari HHI, Irawati Y, Susiyanti M. Successful management of bilateral periorbital necrotising fasciitis with ocular involvement. *BMJ Case Reports*. 2018. <https://doi.org/10.1136/bcr-2017-223457>.
221. Firth GB, Oetzmann von Sochaczewski C, Ramguthy Y, Khalfallah A. Necrotising fasciitis following a supracondylar and an open radius fracture in a child. *SA Orthop J*. 2018;17(2):49–53. <https://doi.org/10.17159/2309-8309/2018/v17n2a9>.
222. Waldhausen JH, Holterman MJ, Sawin RS. Surgical implications of necrotizing fasciitis in children with chickenpox. *J Pediatr Surg*. 1996;31(8):1138–41. [https://doi.org/10.1016/S0022-3468\(96\)90103-7](https://doi.org/10.1016/S0022-3468(96)90103-7).
223. Nissen T, Wynn R. The clinical case report: a review of its merits and limitations. *BMC Research Notes*. 2014;7(1):264. <https://doi.org/10.1186/1756-0500-7-264>.
224. Sullivan TB, Bastrom TP, Marino N, Edmonds EW. Presenting features of extremity necrotizing fasciitis in the pediatric patient: A case-control analysis. *J Pediatr Orthop B*. 2018;27(5):461–6. <https://doi.org/10.1097/BPB.0000000000000493>.
225. Rea WJ, Wyrick WJr. Necrotizing fasciitis. *Ann Surg*. 1970;172(6):957–64.
226. Hansen MB, Rasmussen LS, Svensson M, Chakrakodi B, Bruun T, Madsen MB, Perner A, Garred P, Hyldegaard O, Norrby-Teglund A. INFECT study group Association between cytokine response, the Irinec score and outcome in patients with necrotising soft tissue infection: a multicentre, prospective study. *Sci Rep*. 2017;7:42179. <https://doi.org/10.1038/srep42179>.
227. Moss RL, Musemeche CA, Kosloske AM. Necrotizing fasciitis in children: prompt recognition and aggressive therapy improve survival. *J Pediatr Surg*. 1996;31(8):1142–6. [https://doi.org/10.1016/S0022-3468\(96\)90104-9](https://doi.org/10.1016/S0022-3468(96)90104-9).
228. Patel RA, Binns HJ, Shulman ST. Reduction in pediatric hospitalizations for varicella-related invasive group A streptococcal infections in the varicella vaccine era. *J Pediatr*. 2004;144(1):68–74. <https://doi.org/10.1016/j.jpeds.2003.10.025>.
229. Frère J, Bidet P, Tapiéro B, Rallu F, Minodier P, Bonacorsi S, Bingen E, Ovetchkine P. Clinical and microbiological characteristics of invasive group A streptococcal infections before and after implementation of a universal varicella vaccine program. *Clin Infect Dis*. 2016;62(1):75–7. <https://doi.org/10.1093/cid/civ793>.
230. van der Meulen H, Pernica JM, Roy M, Kam AJ. A 10-year review of necrotizing fasciitis in the pediatric population: Delays to diagnosis and management. *Clin Pediatr (Phila)*. 2017;56(7):627–33. <https://doi.org/10.1177/0009922816667314>.
231. Albrecht J, Meves A, Bigby M. Case reports and case series from lancet had significant impact on medical literature. *J Clin Epidemiol*. 2005;58(12):1227–32. <https://doi.org/10.1016/j.jclinepi.2005.04.003>.
232. Chambers D, Rodgers M, Woolcott N. Not only randomized controlled trials, but also case series should be considered in systematic reviews of rapidly developing technologies. *J Clin Epidemiol*. 2009;62(12):1253–12604. <https://doi.org/10.1016/j.jclinepi.2008.12.010>.
233. Dalziel K, Round A, Stein K, Garside R, Castelnovo E, Payne L. Do the findings of case series studies vary significantly according to methodological characteristics? *Health Technol Assess*. 2005;9(2). <https://doi.org/10.3310/hta9020>.

Ready to submit your research? Choose BMC and benefit from:

- fast, convenient online submission
- thorough peer review by experienced researchers in your field
- rapid publication on acceptance
- support for research data, including large and complex data types
- gold Open Access which fosters wider collaboration and increased citations
- maximum visibility for your research: over 100M website views per year

At BMC, research is always in progress.

Learn more biomedcentral.com/submissions

