**Name of Journal:** *World Journal of Cardiology*

**Manuscript NO:** 49488

**Manuscript Type:** CASE REPORT

***Salmonella typhimurium* myopericarditis: A case report and review of literature**

JinD *et al*.*Salmonella* myopericarditis

David Jin, Chien-Ying Kao, Jonathon Darby, Sonny Palmer

**David Jin,** **Sonny Palmer,** Department of Medicine at St Vincent’s Hospital, The University of Melbourne, Parkville 3052, Australia

**David Jin,** **Chien-Ying Kao, Sonny Palmer,** Department of Cardiology, St Vincent’s Hospital Melbourne, Fitzroy 3065, Australia

**Jonathon Darby,** Department of Infectious Diseases, St Vincent’s Hospital Melbourne, Fitzroy 3065, Australia

**ORCID number:**David Jin (0000-0002-7393-9540); Chien-Ying Kao (0000-0002-2307-9634); Jonathan Darby (0000-0001-5462-5215); Sonny Palmer (0000-0001-5305-1483).

**Author contributions:** Jin D, Darby J, and Palmer S designed the research;Jin D and Kao CY preformed the literature review; Darby J and Palmer S contributed to the writing of the discussion; Jin D and Kao CY wrote the paper.

**Informed consent statement:** All study participants or their legal guardian provided informed written consent about personal and medical data collection prior to study enrolment. Copy of this statement is available upon request.

**Conflict-of-interest statement:** David Jin is funded by a government commonwealth research scholarship. There are no declared conflicts of interest for any of the authors.

**CARE Checklist (2016) statement:** The authors have read the CARE Checklist (2016), and the manuscript was prepared and revised according to the CARE Checklist (2016).

**Open-Access:** This article is an open-access article which was selected by an in-house editor and fully peer-reviewed by external reviewers. It is distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited and the use is non-commercial. See: http://creativecommons.org/licenses/by-nc/4.0/

**Manuscript source:** Unsolicited manuscript

**Corresponding author:** **David Jin,** **MD, Doctor,** Department of Medicine at St Vincent’s Hospital, The University of Melbourne, Parkville 3052, Australia. d.jin2@unimelb.edu.au

**Telephone:** +61-3-92312211

**Received:** June 21, 2019

**Peer-review started:** June 23, 2019

**First decision:** September 21, 2019

**Revised:** November 4, 2019

**Accepted:** November 20, 2019

**Article in press:**

**Published online:**

### **Abstract**

***BACKGROUND***

Non-typhoidal salmonella (NTS) is a rare, but well-established cause of myopericarditis. Presenting symptoms may be varied, however often revolve around the dual presentation of both myopericarditis and infectious diarrhoea. Given the rarity of NTS myopericarditis related myopericarditis, we conducted a systematic review of the literature, identifying 41 previously reported cases.

***CASE SUMMARY***

We present the case of an otherwise healthy 39-year old male, presenting with chest pain in the setting of documented *Salmonella typhimurium* infection. After further investigation with echocardiogram and laboratory blood tests, a diagnosis of NTS associated myopericarditis was made, and the patient received antibiotic treatment with an excellent clinical outcome. Overall, myopericarditis is rare in NTS. Although treatment for myopericarditis has not been well established, there are guidelines for the treatment of NTS infection. In our review, we found that the majority of NTS cases has been pericarditis (27/42, 64.3%), with an average age of 48.3 years, and 71.4% being male. The average mortality across all cases was 31%.

***CONCLUSION***

Myopericarditis is a rare, but potentially serious complication of NTS infection, associated with an increased morbidity and mortality.

**Key words:** *Salmonella typhimurium*; Pericarditis; Myocarditis; Myopericarditis; Non-typhoidal salmonella; Case report

**© The Author(s) 2019.** Published by Baishideng Publishing Group Inc. All rights reserved.

**Core tip:** Myopericarditis can be variable but generally presents with ischaemic sounding chest pain or pleuritic chest pain and cardiac biomarker elevation (troponin I and T). Non-typhoidal salmonella (NTS) generally presents as a non-bloody infectious diarrhoea. *Salmonella enterica* has multiple subtypes, with *Salmonella typhi* and *paratyphi* causing typhoid fever. However, there are a large group of NTS, which may include *Salmonella* *choleraesuis, enteritidis,* and *typhimurium.* Relevant investigations may consist of laboratory blood tests, electrocardiogram, echocardiography, coronary angiography, cardiac magnetic resonance imaging, cardiac biopsy, and faecal culture for *Salmonella*. *Salmonella* is a rare cause of myopericarditis; however, it should be considered when patients with symptoms of myocarditis or pericarditis present with a history of diarrhoea, abdominal pain and fever.

Jin D, Kao CY, Darby J, Palmer S. *Salmonella typhimurium* myopericarditis: A case report and review of literature. *World J Cardiol* 2019; In press

### **INTRODUCTION**

Myocarditis is defined as an inflammatory disorder of the myocardium, formally diagnosed on clinical biopsy, however many cases are often diagnosed clinically[1]. Pericarditis, also inflammatory, is when the inflammation primarily involves the pericardial sac. Given their close anatomical relation, co-inflammation can occur as part of a syndrome known as myopericarditis, however, clinical manifestations are predominantly myocarditic or pericarditic[2]. The aetiology of myopericarditis is varied, ranging from infections (viral being the most common), autoinflammatory conditions, neoplasms, trauma, metabolic and idiopathic[3]. A rare, but potentially serious cause is as a sequelae of Salmonella infection.

Most cases of *Salmonella* myocarditis are associated with typhoid fever (*Salmonella typhi/paratyphi*), complicating up to 5% of all infections, and is well described in literature[4]. We conducted a systematic review of all case studies and case series published on nontyphoidal salmonella (NTS) associated pericarditis and/or myocarditis from January 1970 to March 2019. Both authors (Jin D and Kao CY) searched on PubMed and EMBASE using the search terms ‘Salmonella AND myocarditis’ and ‘Salmonella AND pericarditis’. PubMed was further searched for the combined MeSH values of ‘Myocarditis’ as well as ‘Salmonella (excluding typhi and paratyphi)’. Paediatric and non-human cases were excluded. References of articles were then further reviewed. We aim to discuss a case NTS myopericarditis, as well as reviewing the relevant literature.

**CASE PRESENTATION**

***Chief complaints***

We report a case of a 39-year old male, with no previous medical history, presenting with *Salmonella typhimurium* myopericarditis.

***Personal and family history***

The patient initially presented to our emergency department (ED) with acute chest discomfort, on the background of a four-day history of persistent, watery diarrhoea, occurring three to four times per day. On Day 0 (four days prior to admission), he noticed diffused abdominal cramps, bloating, nausea without vomiting, and fever. There was no history of recent travel, however he had a seven-year-old daughter, who had a one-week history of the same symptoms which had resolved prior to the patient’s presentation. There was no report of blood in the diarrhoea, which was beginning to decrease and form solid motions by Day 4.

However, it was during this stage (Day 4) that the patient noted central chest discomfort, described as a burning sensation, radiating to the axilla and neck, associated with diaphoresis and self-resolving shortness of breath. This was not exacerbated by exercise, however there was some relief with leaning forwards. He initially presented to his General Practitioner (GP), who organised for faecal cultures, before referring onto ED.

***Laboratory examinations***

At presentation to ED, his observations were within normal limits, with no documented fevers or tachycardia. Physical exam was unremarkable. Serial electrocardiogram (ECG, Figure 1) revealed prominent ST elevation (> 2 mm in leads V2-V6, > 1 mm in II/aVF), as well as ST depression in aVR. Investigations revealed a white cell count (WCC) of 7.3 × 109/L, C-reactive protein (CRP) of 84 mg/L, as well as a Troponin I (Abbott Architect) of 14757 ng/L and a creatinine kinase of 594 units/L. Other blood tests such as urea electrolytes and creatinine and liver function tests were unremarkable.

***Imaging examinations***

Chest X-ray showed mild cardiac enlargement, without signs of pulmonary oedema or pneumonia. Faeces microscopy and culture, along with blood cultures were taken, and the patient was admitted without specific antimicrobial treatment. An echocardiogram conducted the next day showed a trivial amount of pericardial fluid. The was no clinical or echocardiographic evidence of tamponade, ventricular dysfunction, or thrombus formation.

During Day 5, we were notified of a *Salmonella* species from the faecal culture organised by the GP. Treatment was commenced with 1 g of ceftriaxone daily. Later that night there was an associated, asymptomatic rise in the Troponin I from the previous nadir of 8915 to 15114 ng/L. Ceftriaxone was increased to 2 g daily, and the Infectious Diseases Unit were consulted. At this stage the repeat faecal culture also identified *Salmonella* species, with negative blood cultures at 48 h. Joint decision at this stage was made to change to azithromycin 500 mg daily for 5 d and to not initiate non-steroidal therapy, given that the initial presenting symptoms had fully resolved. There had been no clinical events of arterial or venous thrombus, combined with no significant echocardiography changes, therefore no anticoagulation was prescribed. After a further period of observation over 24 h, during which the troponin decreased to 11327 ng/L, the patient was discharged home.

Post discharge, at Day 7, the initial presenting blood culture was positive for gram negative bacilli in one aerobic bottle, out of two sets, also identified as *Salmonella typhimurium*, however by this stage the patient was convalescing well at home.

**FINAL DIAGNOSIS**

Myopericarditis in the setting of *Salmonella* *typhimurium* gastroenteritis and bacteraemia.

**TREATMENT**

Two days of ceftriaxone 2 g IV daily, followed by azithromycin 500 mg orally daily for 5 d

**OUTCOME AND FOLLOW-UP**

Clinical and biochemical resolution of myopericarditis and *Salmonella**typhimurium* infection. Patient well with no further complaints at routine one-month follow-up.

### **DISCUSSION**

The presentation of NTS myopericarditis can be varied, but generally is divided into two categories, the symptoms of myopericarditis, and the diarrhoeal syndrome. Although the manifestations of myopericarditis are commonly a spectrum between myocarditis and pericarditis, there is often a predominance of on[2]. Myocarditis typically presents with chest pain, often of a varied nature, and can be impossible to differentiate on history from ischaemic chest pain. Otherwise heart failure symptoms, flu-like symptoms, fatigue, palpitations, syncope, or even sudden cardiac death may be the presenting symptom[5]. Pericarditis is associated with a pleuritic chest pain, often relieved by learning forward, as well as fatigue, palpitations, dyspnoea, and potentially tamponade[5]. The classic exam finding is the pericardial friction rub, often described as a scratching sound best heard over the left sternal edge. Purulent pericarditis, a rare subset in the antibiotic era, should nevertheless be considered given its high morbidity and mortality. Presenting symptoms may include signs of pericarditis, especially if associated with sepsis or bacteraemia, with *Salmonella**aureus* being the most commonly identified organism.

Investigations of relevance in myopericarditis include ECG, echocardiography, laboratory blood tests, biopsy, coronary angiography and cardiac magnetic resonance imaging. ECG changes are varied[6], but typically involve diffuse ST elevation and PR depression, progressing to normalization of segments with subsequent T-wave inversion. However, given this can also manifest as focal ST elevation, combined with the fact that the pain can be ischaemic in nature, differentiation from acute coronary syndromes (ACS) is often required. This is most frequently done with interventional angiography, or more recently computed tomography coronary angiography. Aside from raised troponin, inflammatory markers such as WCC and CRP are often raised, however this has not been shown to help differentiate NTS as a cause[7]. Echocardiography is another critical area of investigation, as this can help identify ventricular dysfunction, valvular incompetence and thrombus in myocarditis[8], as well as the extent of pericardial involvement, ranging from completely normal to cardiac tamponade in pericarditis[9]. Cardiac magnetic resonance imaging is another investigation that can be potentially used, as it can accurately assess inflammation in either the pericardium or myocardium, as well as help differentiate between ACS[10]. Definitive diagnosis of myocarditis requires endocardial biopsy, however indication revolves around whether a biopsy result would change patient management, and thus is rarely conducted in those with normal or only mildly impaired ventricular function[11]. Biopsy is most frequently performed in cases of fulminant heart failure, heart failure with rhythm disturbance, or when there is peripheral eosinophilia, suggestive of eosinophilic myocarditis.

The most recognised infection from *Salmonella* is typhoid fever, also known as enteric fever, caused by *Salmonella enterica* serotype Typhi (formerly *Salmonella typhi*), as well as *Salmonella paratyphi* (*Salmonella enterica* serotype *paratyphi*). Due to a nomenclature change, within Salmonella there are now two species; *bongori* and *enteric*[12]. *Salmonella enterica*, which causes the majority of infections, contains 6 subspecies, of which the most clinically relevant is *Salmonella enterica* subspecies *enterica*. These are then further divided into serovars, with the most common including: *Salmonella choleraesuis*, *Salmonella enteritidis,* and *Salmonella typhimurium.* These organisms make up the group known as NTS.

NTS often manifests within 72 h of exposure to the offending pathogen and is usually associated with faecal-oral contamination. The most common presenting symptoms by far is gastroenteritis[13], associated with watery, non-bloody diarrhoea, abdominal cramps, nausea and vomiting, as well as fever.

In our review of the literature (Table 1), we found 42 reported cases of NTS (Table 2), with 9 myocarditis, 6 myopericarditis and 27 cases of pericarditis. Overall, we found that *Salmonella enteritidis* was the most common organism, representing 18 (42.9%) of all reported cases, with *Salmonella typhimurium* at 31.7%. Males consisted 71.4% of the cases, and the average age of patients was 48.3 years. In the case studies that we have identified, the overall mortality rate was 31%, and up to 77.8% in myocarditis cases, compared to 14.8% in pericarditis. Tamponade was the most commonly reported complication, especially in pericarditis, at 54.3%, whilst ventricular rupture was the most commonly reported complication of myocarditis. However, this is limited by both reporting and publication bias, and by the fact that most deaths and myocarditis cases occurred earlier in time, prior to modern diagnostic techniques and treatment.

The mainstay of therapy in treating the inflammation and pain associated with myopericarditis is non-steroidal anti-inflammatory drugs (NSAIDs)[3]. However when there is a predominant myocarditic component, NSAIDs are often reconsidered, as animal models show increased inflammation and mortality in viral myocarditis[14]. Corticosteroids are also potentially used, but should only be considered in cases of ongoing uncontrolled inflammation, as there is minimal data to recommend its routine use, and there is association with recurrent myocarditis[15]. Anticoagulation can be considered in specific patients, similar to the indications in non-ischaemic dilated cardiomyopathy[16]. These would be if there were new onset AF, clinical or radiographical evidence of arterial or venous thromboembolism, thrombus formation on the echogardiogram, or significant ventricular dysfunction. If treatment was indicated, evidence currently leans towards anticoagulation with warfarin or a Direct Oral Anti-Coagulant, as opposed to single-agent treatment with an antiplatelet[17]. If there are concurrent symptoms of heart failure, routine heart failure treatment should be initiated, including diuretics, angiotensin converting enzyme inhibition, and extended release beta blocker treatment. Invasive treatment is often limited to coronary angiography when differentiating from ACS, as well as pericardiocentesis in the setting of large pericardial effusions with features suggestive of developing or frank cardiac tamponade.

Lastly, it is also important to treat the underlying *Salmonella* infection, however guidelines vary secondary to local antimicrobial susceptibility patterns. After clinical rehydration, current Australian guidelines[18], recommend treatment with intravenous therapy initially, such as ceftriaxone (2 g IV daily), or ciprofloxacin (400 mg twice-daily), before an oral tail of ciprofloxacin/azithromycin, determined by the severity of the infection.

At this stage, there is very limited high-quality data on long-term prognosis and complications in patients diagnosed with myopericarditis[3]. Nevertheless, it appears that survival rates in idiopathic and infectious myocarditis are overall quite favourable, especially the predominant pericarditis subtype[19]. The main complications are the development or non-resolution of heart failure, cardiomyopathy, arrhythmias, and sudden cardiac death, especially if there is significant myocardial scarring. Routine follow up in the acute phase with echocardiography is recommended, especially if there are clinical or radiological signs of heart failure.

### **CONCLUSION**

The presentation of NTS myopericarditis is varied, however it revolves around two main areas, the symptoms of myocarditis and pericarditis, as well as the infectious symptoms of diarrhoea accompanying Salmonella infection. Definitive diagnosis with biopsy is rarely undertaken, as this is usually a clinical diagnosis from the clinical history and examination, ECG, troponin and echocardiogram, as well as a stool culture for the NTS. There is a lack of consensus regarding the treatment of myopericarditis, however there are well established antibiotic guidelines for NTS. Although NTS is a rare cause of myopericarditis, given the severity of potential sequelae, remains a worthwhile consideration when patients present with symptoms of both infectious diarrhoea and myopericarditis.

### **REFERENCES**

1 **Caforio AL**, Pankuweit S, Arbustini E, Basso C, Gimeno-Blanes J, Felix SB, Fu M, Heliö T, Heymans S, Jahns R, Klingel K, Linhart A, Maisch B, McKenna W, Mogensen J, Pinto YM, Ristic A, Schultheiss HP, Seggewiss H, Tavazzi L, Thiene G, Yilmaz A, Charron P, Elliott PM; European Society of Cardiology Working Group on Myocardial and Pericardial Diseases. Current state of knowledge on aetiology, diagnosis, management, and therapy of myocarditis: a position statement of the European Society of Cardiology Working Group on Myocardial and Pericardial Diseases. *Eur Heart J* 2013; **34**: 2636-2648, 2648a-2648d [PMID: 23824828 DOI: 10.1093/eurheartj/eht210]

2 **Imazio M**, Trinchero R. The spectrum of inflammatory myopericardial diseases. *Int J Cardiol* 2010; **144**: 134 [PMID: 19178962 DOI: 10.1016/j.ijcard.2008.12.118]

3 **Imazio M**, Trinchero R. Myopericarditis: Etiology, management, and prognosis. *Int J Cardiol* 2008; **127**: 17-26 [PMID: 18221804 DOI: 10.1016/j.ijcard.2007.10.053]

4 **Huang DB**, DuPont HL. Problem pathogens: extra-intestinal complications of Salmonella enterica serotype Typhi infection. *Lancet Infect Dis* 2005; **5**: 341-348 [PMID: 15919620 DOI: 10.1016/S1473-3099(05)70138-9]

5 **Ammirati E**, Cipriani M, Moro C, Raineri C, Pini D, Sormani P, Mantovani R, Varrenti M, Pedrotti P, Conca C, Mafrici A, Grosu A, Briguglia D, Guglielmetto S, Perego GB, Colombo S, Caico SI, Giannattasio C, Maestroni A, Carubelli V, Metra M, Lombardi C, Campodonico J, Agostoni P, Peretto G, Scelsi L, Turco A, Di Tano G, Campana C, Belloni A, Morandi F, Mortara A, Cirò A, Senni M, Gavazzi A, Frigerio M, Oliva F, Camici PG; Registro Lombardo delle Miocarditi. Clinical Presentation and Outcome in a Contemporary Cohort of Patients With Acute Myocarditis. *Circulation* 2018; **138**: 1088-1099 [PMID: 29764898 DOI: 10.1161/CIRCULATIONAHA.118.035319]

6 **Imazio M**, Cecchi E, Demichelis B, Chinaglia A, Ierna S, Demarie D, Ghisio A, Pomari F, Belli R, Trinchero R. Myopericarditis versus viral or idiopathic acute pericarditis. *Heart* 2008; **94**: 498-501 [PMID: 17575329 DOI: 10.1136/hrt.2006.104067]

7 **Satapathy S**, Bhuyan K, Nayak SR. Salmonella Myocarditis: Suspecting and Estimating the Associated Clinical Complications. *Clin Med Rev Cardiol* 2016 [DOI: 10.4137/CMRC.S38652]

8 **Pinamonti B**, Alberti E, Cigalotto A, Dreas L, Salvi A, Silvestri F, Camerini F. Echocardiographic findings in myocarditis. *Am J Cardiol* 1988; **62**: 285-291 [PMID: 3400607 DOI: 10.1016/0002-9149(88)90226-3]

9 **Chandraratna PA**. Echocardiography and Doppler ultrasound in the evaluation of pericardial disease. *Circulation* 1991; **84**: I303-I310 [PMID: 1884500 DOI: 10.1002/ccd.1810240123]

10 **Friedrich MG**, Sechtem U, Schulz-Menger J, Holmvang G, Alakija P, Cooper LT, White JA, Abdel-Aty H, Gutberlet M, Prasad S, Aletras A, Laissy JP, Paterson I, Filipchuk NG, Kumar A, Pauschinger M, Liu P; International Consensus Group on Cardiovascular Magnetic Resonance in Myocarditis. Cardiovascular magnetic resonance in myocarditis: A JACC White Paper. *J Am Coll Cardiol* 2009; **53**: 1475-1487 [PMID: 19389557 DOI: 10.1016/j.jacc.2009.02.007]

11 **Yancy CW**, Jessup M, Bozkurt B, Butler J, Casey DE Jr, Drazner MH, Fonarow GC, Geraci SA, Horwich T, Januzzi JL, Johnson MR, Kasper EK, Levy WC, Masoudi FA, McBride PE, McMurray JJ, Mitchell JE, Peterson PN, Riegel B, Sam F, Stevenson LW, Tang WH, Tsai EJ, Wilkoff BL. 2013 ACCF/AHA guideline for the management of heart failure: executive summary: a report of the American College of Cardiology Foundation/American Heart Association Task Force on practice guidelines. *Circulation* 2013; **128**: 1810-1852 [PMID: 23741057 DOI: 10.1161/CIR.0b013e31829e8807]

12 **Tindall BJ**, Grimont PA, Garrity GM, Euzéby JP. Nomenclature and taxonomy of the genus Salmonella. *Int J Syst Evol Microbiol* 2005; **55**: 521-524 [PMID: 15653930 DOI: 10.1099/ijs.0.63580-0]

13 **Saphra I**, WINTER JW. Clinical manifestations of salmonellosis in man; an evaluation of 7779 human infections identified at the New York Salmonella Center. *N Engl J Med* 1957; **256**: 1128-1134 [PMID: 13452006 DOI: 10.1056/NEJM195706132562402]

14 **Costanzo-Nordin MR**, Reap EA, O'Connell JB, Robinson JA, Scanlon PJ. A nonsteroid anti-inflammatory drug exacerbates Coxsackie B3 murine myocarditis. *J Am Coll Cardiol* 1985; **6**: 1078-1082 [PMID: 2995470 DOI: 10.1016/S0735-1097(85)80312-0]

15 **Chen HS**, Wang W, Wu SN, Liu JP. Corticosteroids for viral myocarditis. *Cochrane Database Syst Rev* 2013; **(10)**: CD004471 [PMID: 24136037 DOI: 10.1002/14651858.CD004471.pub3]

16 **Schultz JC**, Hilliard AA, Cooper LT Jr, Rihal CS. Diagnosis and treatment of viral myocarditis. *Mayo Clin Proc* 2009; **84**: 1001-1009 [PMID: 19880690 DOI: 10.1016/S0025-6196(11)60670-8]

17 **Carazo M**, Berger JS, Reyentovich A, Katz SD. Role of Antiplatelet Therapy and Anticoagulation in Nonischemic Cardiomyopathy. *Cardiol Rev* 2016; **24**: 211-217 [PMID: 26501990 DOI: 10.1097/CRD.0000000000000094]

18 **Acute infectious diarrhoea**. Therapeutic Guidelines Ltd [Internet]. 2019 [cited April 29, 2019]. Available from: https://tgldcdp.tg.org.au/searchAction?appendedInputButtons=Acute%20infectious%20diarrhoea

19 **Imazio M**, Brucato A, Barbieri A, Ferroni F, Maestroni S, Ligabue G, Chinaglia A, Cumetti D, Della Casa G, Bonomi F, Mantovani F, Di Corato P, Lugli R, Faletti R, Leuzzi S, Bonamini R, Modena MG, Belli R. Good prognosis for pericarditis with and without myocardial involvement: results from a multicenter, prospective cohort study. *Circulation* 2013; **128**: 42-49 [PMID: 23709669 DOI: 10.1161/CIRCULATIONAHA.113.001531]

20 **Bengtsson E**, HEDLUND P, NISELL A, NORDENSTAM H. An epidemic due to Salmonella typhimurium (Breslau) occurring in Sweden in 1953; with special reference to clinical complications, bacteriology, serology, antibiotic treatment, and morbid anatomy. *Acta Med Scand* 1955; **153**: 1-20 [PMID: 13292172]

21 **Sanders V**, Misanik LF. Salmonella myocarditis. report of a case with ventricular rupture. *Am Heart J* 1964; **68**: 682-685 [PMID: 14222407 DOI: 10.1016/0002-8703(64)90278-9]

22 **Shilkin KB**. Salmonella typhimurium pancarditis. *Postgrad Med J* 1969; **45**: 40-43 [PMID: 4892937 DOI: 10.1136/pgmj.45.519.40]

23 **Schatz JW**, Wiener L, Gallagher HS, Eberly RJ. Salmonella pericarditis: an unusual complication of myocardial infarction. *Chest* 1973; **64**: 267-269 [PMID: 4579706 DOI: 10.1378/chest.64.2.267]

24 **Webster J**, Petersen J, Edward N. Cardiac tamponade and acute renal failure following Salmonella agona pericarditis. *Postgrad Med J* 1977; **53**: 265-266 [PMID: 876935 DOI: 10.1136/pgmj.53.619.265]

25 **Simonsen J**, Falk E. A case of sudden cardiac death in connection with Salmonella typhimurium infection. *Forensic Sci Int* 1980; **16**: 283-287 [PMID: 7009351 DOI: 10.1016/0379-0738(80)90214-5]

26 **Götz M**, Juchems R. [Myocarditis caused by Salmonella typhimurium]. *Klin Wochenschr* 1983; **61**: 1153-1157 [PMID: 6228687 DOI: 10.1007/BF01530844]

27 **Martínez-Martínez L**, Mesa E, Rodríguez JE, Sánchez MP, Ugarte J, Algora Weber A, Dámaso D, Daza RM, Mendaza P. [Bacteremia associated with mycotic aneurysm of the transversal aortic arch and myocarditis caused by Salmonella enteritidis]. *Enferm Infecc Microbiol Clin* 1989; **7**: 97-99 [PMID: 2490676]

28 **Burt CR**, Proudfoot JC, Roberts M, Horowitz RH. Fatal myocarditis secondary to Salmonella septicemia in a young adult. *J Emerg Med* 1990; **8**: 295-297 [PMID: 2373838 DOI: 10.1016/0736-4679(90)90009-K]

29 **Dunbabin DW**. Pericarditis due to Salmonella dublin. *Postgrad Med J* 1990; **66**: 252-253 [PMID: 2362900 DOI: 10.1136/pgmj.66.773.252-a]

30 **Doig JC**, Hilton CJ, Reid DS. Salmonella: a rare cause of subacute effusive-constrictive pericarditis. *Br Heart J* 1991; **65**: 296-297 [PMID: 2039677 DOI: 10.1136/hrt.65.5.296]

31 **Clesham GJ**, Davies GJ. Bacterial pericarditis caused by Salmonella enteritidis phage type 1. *Int J Cardiol* 1993; **41**: 241-243 [PMID: 8288415 DOI: 10.1016/0167-5273(93)90122-W]

32 **Li EK**, Cohen MG, Ho AK, Cheng AF. Salmonella bacteraemia occurring concurrently with the first presentation of systemic lupus erythematosus. *Br J Rheumatol* 1993; **32**: 66-67 [PMID: 8422563 DOI: 10.1093/rheumatology/32.1.66]

33 **Yang CH**, Chen KJ, Tseng HH, Yang CJ, Liu JD. Salmonella pericarditis and empyema: a case report. *Zhonghua Yi Xue Za Zhi (Taipei)* 1995; **56**: 199-204 [PMID: 8854443]

34 **Victor F**, Gras D, Le Breton H, Gras S, Amelot J, Pony JC. [Salmonella enteritidis pericarditis. Apropos of a case and review of the literature]. *Arch Mal Coeur Vaiss* 1997; **90**: 301-303 [PMID: 9181041]

35 **Kiuchi K**, Endo T, Nejima J, Okamatsu K, Takayama M, Takano T, Hayakawa H. Purulent pericarditis with tamponade caused by Salmonella enteritidis. *Jpn Circ J* 1998; **62**: 139-141 [PMID: 9559435 DOI: 10.1253/jcj.62.139]

36 **Badawi R**, Nageh T, Walker D, Wray R. Nontyphoidal salmonella pericarditis: a case of Salmonella typhimurium phage type 2 pericarditis. *Int J Cardiol* 2002; **82**: 187-189 [PMID: 11853909 DOI: 10.1016/S0167-5273(01)00617-9]

37 **Pace F**, Fanfarillo F, Giorgino F, Baratta L. Salmonella enteritidis pericarditis: case report and review of the literature. *Ann Ital Med Int* 2002; **17**: 189-192 [PMID: 12402668]

38 **Salavert M**, Navarro V, Roig P. [Purulent pericarditis due to Salmonella enterica subsp. arizonae]. *Enferm Infecc Microbiol Clin* 2002; **20**: 47-49 [PMID: 11820989 DOI: 10.1016/S0213-005X(02)72738-9]

39 **Candel FJ**, Roca-Arbonés V, Núñez MJ, Arroyo C, Valdivia A, Téllez MJ, Picazo JJ. A rare cause of pericarditis. *Clin Microbiol Infect* 2003; **9**: 1261-1263 [PMID: 14687001 DOI: 10.1111/j.1469-0691.2003.00802.x]

40 **Yoshioka H**, Shigemitsu K, Takeuchi M, Mori S, Imaizumi M, Ueda Y. Salmonella pericarditis in a patient with primary idiopathic chylopericardium. *Jpn J Thorac Cardiovasc Surg* 2003; **51**: 16-17 [PMID: 12645149 DOI: 10.1007/s11748-003-0059-7]

41 **Arruvito L**, Ber MG, Martínez Martínez JA. [Purulent pericarditis with pericardial tamponade caused by Streptococcus agalactiae and Salmonella enterica no typhi]. *Medicina (B Aires)* 2004; **64**: 340-342 [PMID: 15338978]

42 **Can F**, Demirbilek M, Erdem B, Ciftci U, Tunaoglu M, Laleli Y. A purulent pericarditis caused by Salmonella typhimurium. *J Med Microbiol* 2004; **53**: 1051-1052 [PMID: 15358830 DOI: 10.1099/jmm.0.05449-0]

43 **Fernández Guerrero ML**, Aguado JM, Arribas A, Lumbreras C, de Gorgolas M. The spectrum of cardiovascular infections due to Salmonella enterica: a review of clinical features and factors determining outcome. *Medicine (Baltimore)* 2004; **83**: 123-138 [PMID: 15028966 DOI: 10.1097/01.md.0000125652.75260.cf]

44 **Hoag JB**, Sessler CN. A comprehensive review of disseminated Salmonella arizona infection with an illustrative case presentation. *South Med J* 2005; **98**: 1123-1129 [PMID: 16351033 DOI: 10.1097/01.smj.0000177346.07719.00]

45 **Górecki B**, Flasiński J, Górski J. [Patient with purulent pericarditis caused by Salmonella enteritidis complicated by tamponade]. *Kardiol Pol* 2008; **66**: 664-7; discussion 667-8 [PMID: 18626836]

46 **Sahu M**, Sujatha S, Dr C, Parija SC. Pericardial effusion - an unusual manifestation of salmonellosis: a case report. *Cases J* 2008; **1**: 375 [PMID: 19061513 DOI: 10.1186/1757-1626-1-375]

47 **Takamiya Y**, Shirai K, Fujino M, Miller N, Tsuchiya Y, Okabe M, Saku K. Purulent pericarditis with Salmonella enteritidis in a patient with CD4/CD8 depression. *J Cardiol* 2008; **51**: 201-204 [PMID: 18522796 DOI: 10.1016/j.jjcc.2007.12.004]

48 **Hibbert B**, Costiniuk C, Hibbert R, Joseph P, Alanazi H, Simard T, Dennie C, Angel JB, O'Brien ER. Cardiovascular complications of Salmonella enteritidis infection. *Can J Cardiol* 2010; **26**: 323-325 [PMID: 20931102 DOI: 10.1016/S0828-282X(10)70444-X]

49 **Tseng JR**, Lee MJ, Lin JL, Yen TH. Definite and probable septic pericarditis in hemodialysis. *Ren Fail* 2010; **32**: 1177-1182 [PMID: 20954978 DOI: 10.3109/0886022X.2010.516858]

50 **Ortiz D**, Siegal EM, Kramer C, Khandheria BK, Brauer E. Nontyphoidal cardiac salmonellosis: two case reports and a review of the literature. *Tex Heart Inst J* 2014; **41**: 401-406 [PMID: 25120393 DOI: 10.14503/THIJ-13-3722]

51 **Chand G**, Jhaj R, Sanam K, Sinha P, Alexander P. Pericardial salmonella with cardiac tamponade and ventricular wall rupture: A case report. *Ann Med Surg (Lond)* 2016; **7**: 83-86 [PMID: 27141304 DOI: 10.1016/j.amsu.2016.03.024]

52 **Zaman T**, Vinayak A, Sonti R. Salmonella Enteritidis Myopericarditis Progressing to Cardiac Tamponade. *Chest* 2015; **148**: 266A [DOI: 10.1378/chest.2243595]

53 **Dawar R**, Ganjoo A, Imdadi F, Bhandari V. Multidrug Resistant Invasive Nontyphoidal Salmonella Isolated from and Masquerading Healed Tubercular Constrictive Pericarditis and Study of Virulence Markers. *Cureus* 2017; **9**: e1198 [PMID: 28560124 DOI: 10.7759/cureus.1198]

54 **Kuo CC**, Yu WL, Lee CH, Wu NC. Purulent constrictive pericarditis caused by Salmonella enteritidis in a patient with adult-onset Still's disease: A case report. *Medicine (Baltimore)* 2017; **96**: e8949 [PMID: 29390286 DOI: 10.1097/MD.0000000000008949]

55 **Suzuki A**, Tanaka T, Ohba K, Ito N, Sakai Y, Kaneko A, Machii M, Nonaka D, Goto Y, Takase H. Purulent Pericarditis with Salmonella enterica Subspecies arizona in a Patient with Type 2 Diabetes Mellitus. *Intern Med* 2017; **56**: 2171-2174 [PMID: 28781305 DOI: 10.2169/internalmedicine.8293-16]

56 **Ezad S**, McGee M, Murch S. A Case of Salmonella typhimurium Myocarditis Confirmed on Cardiac Magnetic Resonance Imaging. *Heart Lung Circ* 2018; **27**: S207 [DOI: 10.1016/j.hlc.2018.06.371]

57 **Sundbom P**, Suutari AM, Abdulhadi K, Broda W, Csegedi M. *Salmonella enteritidis* causing myocarditis in a previously healthy 22-year-old male. *Oxf Med Case Reports* 2018; **2018**: omy106 [PMID: 30487991 DOI: 10.1093/omcr/omy106]

58 **Saddler K**, Castro-Lainez MT, Deliz-Aguirre R, Muñoz J, Aguilar Espinal JA, Sierra-Hoffman M, Chandna H, Howel A, Midturi J, Winn R. Nontyphoidal *Salmonella* purulent pericarditis presenting with pericardial tamponade in a patient on infliximab therapy. *IDCases* 2019; **15**: e00500 [PMID: 30788216 DOI: 10.1016/j.idcr.2019.e00500]

**P-Reviewer:** Kharlamov AN **S-Editor:** Yan JP

**L-Editor:** **E-Editor:**

**Specialty type:** Cardiac and cardiovascular systems
**Country of origin:** Australia
**Peer-review report classification**
**Grade A (Excellent):** 0
**Grade B (Very good):** 0
**Grade C (Good):** C
**Grade D (Fair):** 0 **Grade E (Poor):** 0

**Table 1 Non-typhoidal salmonella pericarditis and myocarditis**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Author | Relevant medical history | Age and sex | Cardiac manifestation | Organism | Complications | Outcome |
| Bengtsson *et al*[20], 1955 | NA | 50F | Myocarditis | *Salmonella typhimurium* | NA | Deceased |
| Bengtsson *et al*[20], 1955 | NA | 51M | Myocarditis | *Salmonella typhimurium* | NA | Deceased |
| Sanders *et al*[21], 1964 | NA | 62F | Myocarditis | *Salmonella choleraesuis* | Ventricular Rupture | Deceased |
| Shilkin *et al*[22], 1969 | SLE | 61M | Myopericarditis | *Salmonella typhimurium* | Endocarditis | Deceased |
| Schatz *et al*[23], 1973 | NA | 62M | Myopericarditis | *Salmonella typhimurium* | Tamponade  | Deceased |
| Webster *et al*[24], 1977 | NA | 19F | Myopericarditis | *Salmonella agona* | NA | Survived |
| Simonsen *et al*[25], 1980 | NA | 24M | Myocarditis | *Salmonella typhimurium* | NA | Deceased |
| Götz *et al*[26], 1983 | NA | 53M | Myocarditis | *Salmonella typhimurium* | NA | Deceased |
| Martínez-Martínez *et al*[27], 1989 | NA | 60M | Myocarditis | *Salmonella enteritidis* | Mycotic aneurysms of aorta | Deceased |
| Burt *et al*[28], 1990 | NA | 29M | Myocarditis | *Salmonella* *Heidelberg* | VF | Deceased |
| Dunbabin *et al*[29], 1990 | Chemotherapy | 52F | Pericarditis | *Salmonella* *Dublin* | Tamponade | Deceased |
| Doig *et al*[30], 1991 | NA | 36F | Pericarditis | *Salmonella enteritidis* | Tamponade | Survived |
| Clesham *et al*[31], 1993 | NA | 45M | Pericarditis | *Salmonella enteritidis* | Tamponade | Survived |
| Li *et al*[32], 1993 | NA | 22F | Pericarditis | *Salmonella enteritidis* | NA | Survived |
| Yang *et al*[33], 1995 | NA | 54F | Pericarditis | *Salmonella typhimurium* | NA | Survived |
| Victor *et al*[34], 1997 | NA | 71M | Pericarditis | *Salmonella enteritidis* | NA | Survived |
| Kiuchi *et al*[35], 1998 | ITP (prednisolone) | 39M | Pericarditis | *Salmonella enteritidis* | Tamponade | Survived |
| Badawi *et al*[36], 2002 | NA | 48M | Pericarditis | *Salmonella typhimurium* | NA | Survived |
| Pace *et al*[37], 2002 | NA | 65M | Pericarditis | *Salmonella enteritidis* | Tamponade | Survived |
| Salavert *et al*[38], 2002 | NA | 61M | Pericarditis | *Salmonella* *arizonae* | Tamponade | Survived |
| Candel *et al*[39], 2003 | HIV | 37M | Pericarditis | *Salmonella* *Derby* | NA | Survived |
| Yoshioka *et al*[40], 2003 | NA | 40M | Pericarditis | *Salmonella enteritidis* | NA | Survived |
| Arruvito *et al*[41], 2004 | Arthritis (steroids) | 75M | Pericarditis | *Salmonella* *enterica* | Tamponade | Deceased |
| Can *et al*[42], 2004 | NA | 42M | Pericarditis | *Salmonella typhimurium* | NA | Deceased |
| Fernández Guerrero *et al*[43], 2004 | SLE (prednisolone and azathioprine) | 23F | Pericarditis | *Salmonella typhimurium* | Tamponade | Survived |
| Fernández Guerrero *et al*[43], 2004 | NA | 66M | Myopericarditis | *Salmonella enteritidis* | NA | Survived |
| Hoag *et al*[44], 2005 | HIV | 47F | Pericarditis | *Salmonella* *arizonae* | Tamponade | Survived |
| Górecki *et al*[45], 2008 | RA (steroids)ESRF (on HDx) | 64M | Pericarditis | *Salmonella enteritidis* | Tamponade | Survived |
| Sahu *et al*[46], 2008 | Hodgkin’s lymphoma | 23M | Pericarditis | *Salmonella typhimurium* | NA | Survived |
| Takamiya *et al*[47], 2008 | CD4/CD8 depression (ratio = 0.81) | 65M | Pericarditis | *Salmonella enteritidis* | NA | Survived |
| Hibbert *et al*[48], 2010 | NA | 25M | Myopericarditis | *Salmonella enteritidis*  | NA | Survived |
| Tseng *et al*[49], 2010 | ESRF | 66M | Pericarditis | *Salmonella* *enterica* | Tamponade  | Survived |
| Tseng *et al*[49], 2010 | ESRF | 82M | Pericarditis | *Salmonella enteritidis* | Tamponade | Deceased |
| Ortiz *et al*[50], 2014 | SLE (prednisolone) | 62M | Pericarditis | *Salmonella enteritidis* | Tamponade | Survived |
| Chand *et al*[51], 2015 | NA | 67M | Pericarditis | *Salmonella enteritidis* | Tamponade | Survived |
| Zaman *et al*[52], 2015 | NA | 67M | Myopericarditis | *Salmonella enteritidis* | Tamponade | Survived |
| Dawar *et al*[53], 2017 | NA | 46F | Pericarditis | *Salmonella typhimurium* | NA | Survived |
| Kuo *et al*[54], 2017 | Adult onset Still’s disease(methylprednisolone/prednisolone) | 30F | Pericarditis | *Salmonella enteritidis* | Tamponade | Survived |
| Suzuki *et al*[55], 2017 | NA | 31M | Pericarditis | *Salmonella* *arizonae* | Tamponade | Survived |
| Ezad *et al*[56], 2018  | NA | 29F | Myocarditis | *Salmonella typhimurium* | NA | Survived |
| Sundbom *et al*[57], 2018  | NA | 22M | Myocarditis | *Salmonella enteritidis* | NA | Survived |
| Saddler *et al*[58], 2019  | Crohn’s disease (Infliximab) | 57M | Pericarditis | *Salmonella* *enterica* | Tamponade | Survived |

NA: Not applicable; SLE: Systemic lupus erythematosus; ESRF: End-stage renal failure; HIV: Human immunodeficiency virus; RA: Rheumatoid arthritis; ITP: Idiopathic thrombocytopenic purpura; M: Male; F: Female.

**Table 2 Summary of non-typhoidal salmonella cases**

| Cardiac Manifestation (Cases) | Organisms (Number of cases) | Mortality |
| --- | --- | --- |
| Myocarditis (9) | *Salmonella typhimurium* (5)*Salmonella enteritidis* (2)*Salmonella choleraesuis* (1)*Salmonella* *Heidelberg* (1) | 77.8% (7/9) |
| Myopericarditis (6) | *Salmonella* *enteritidis* (3)*Salmonella* *typhimurium* (2)*Salmonella* *agona* (1) | 33.3% (2/6) |
| Pericarditis (27) | *Salmonella* *enteritidis* (13)*Salmonella* *typhimurium* (6)*Salmonella arizonae* (3)*Salmonella enterica* (3)*Salmonella* *Derby* (1)*Salmonella* *Dublin* (1) | 14.8% (4/27) |
| Total (42) | *Salmonella* *enteritidis* (18)*Salmonella* *typhimurium* (13)*Salmonella arizonae* (3)*Salmonella enterica* (3)*Salmonella* *agona* (1)*Salmonella* *choleraesuis* (1)*Salmonella* *Derby* (1)*Salmonella* *Dublin* (1)*Salmonella* *Heidelberg* (1) | 31% (13/42) |

**Figure 1 Electrocardiography from admission, showing diffuse ST elevation and mild ST depression in automatic voltage regulator.**