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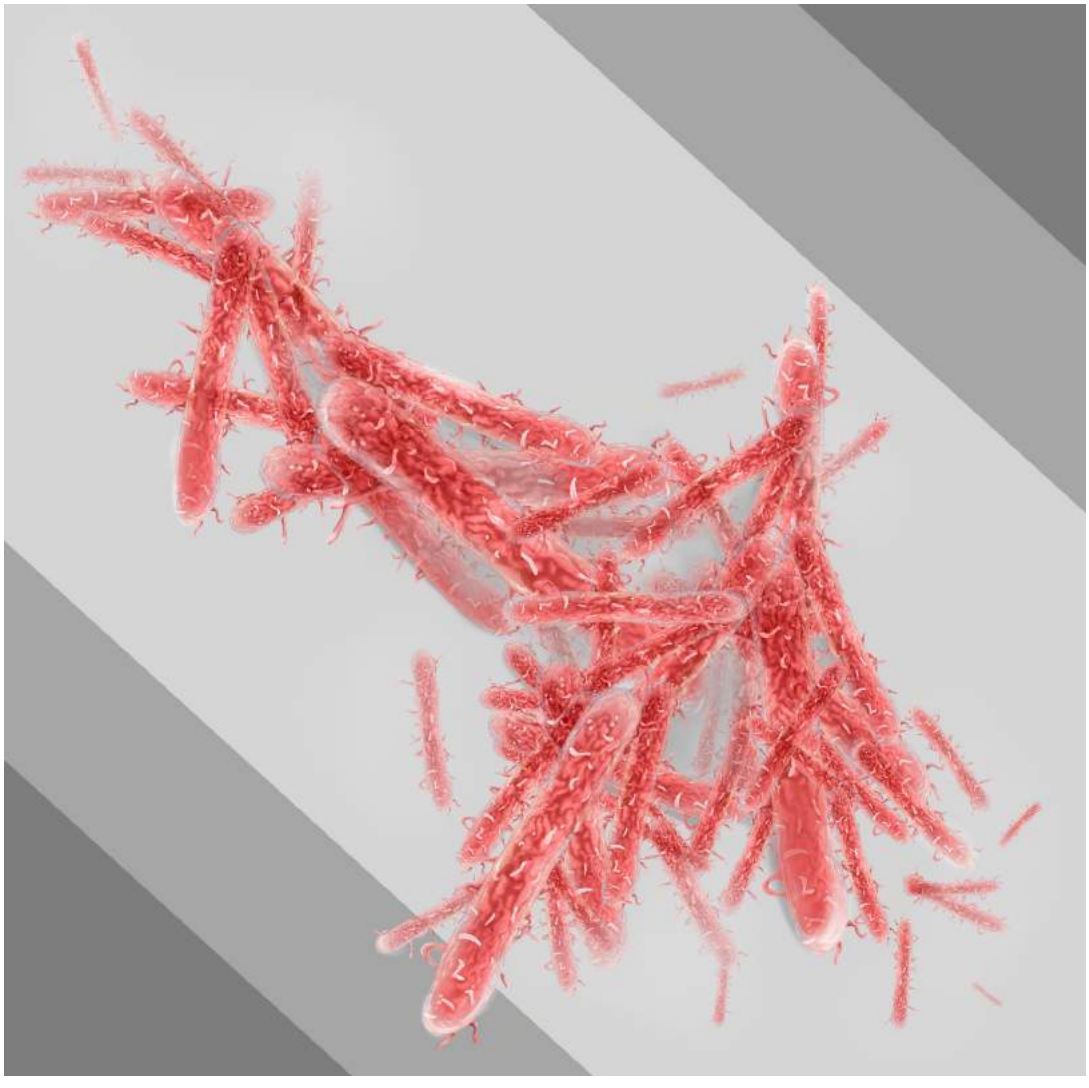
Fall, 2017



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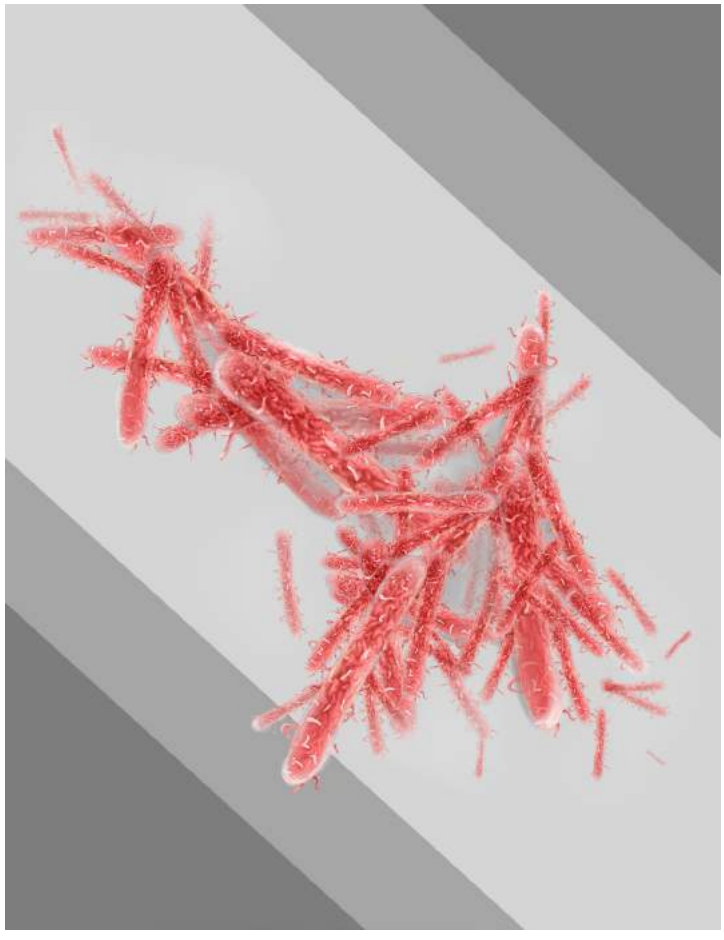

Salmonella

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Salmonella Typhimurium is a bacterium that is ingested through food and is typically found in the intestine which causes gastroenteritis in humans. This bacterium causes the ratio between absorption and secretion to become unbalanced which leads to a fever and diarrhea.

This illustration of the *Salmonella Typhimurium* bacteria was first drawn in Illustrator and then rendered in Photoshop. I chose to illustrate bacteria because I enjoy learning about the body on a molecular level and because I loved the structure of this particular bacterium. I was drawn to the beauty of the structure itself, with its textured pill-shape and the elegant tendrils and fibers that come from its body. The unique qualities of the bacterium were exciting to illustrate. I also was fascinated with how this small bacterium can cause such large problems so quickly in the human body; that this tiny organism can throw the entire gastrointestinal system into disarray. This is a very beautiful organism and I enjoyed learning about it and illustrating it.

Refracture of distal radius and hardware repair in the setting of trauma

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Distal radius fractures are one of the most common fractures in the elderly. Falls and motor vehicle collisions lead to increased risk for this type of fracture. A 73-year-old female had a previous history of distal radius fracture with repair by open reduction and internal fixation. She was involved in a motor vehicle collision that refractured the distal radius. The plate was bent and required removal, which is a very rare but potentially serious complication. Surgery was performed to fix the open reduction and internal fixation with volar locking plates while removing damaged hardware. Only a select few cases have reported hardware failure as a cause of complications. Among those cases, high-energy activities and maintained stress on the hardware were likely causes. Distal radius fractures are the most common upper extremity fracture in the elderly. We highlight a unique case of refracture in the setting of trauma with prior hardware failure and describe the strategy for hardware repair.

Keywords: *volar locking plate; distal radius fracture; open reduction; internal fixation; traumatic refracture.*

LEARNING POINTS

1. Distal radius fractures are common in the elderly following trauma.
2. Volar locking plates offer a unique tool for surgical repair.
3. Locking plates are useful for hardware repair in the setting of refracture.
4. It is important to be aware of complications associated with locking plates such as median nerve compression, nonunion, tendon irritation, and regional pain syndrome.

BACKGROUND

Distal radius fractures are the most common upper extremity fracture in the elderly. Falls and high-impact injuries are common causes of these fractures.[1] The fractures often require reduction and internal fixation.[2] Twenty-five percent of fixations result in complications including compartment syndrome, regional pain syndrome, nerve and tendon injury, and nonunion injuries.[3] Very rarely, however, are the complications the result of early hardware failure.[4] A consensus on treatment approach for distal radius fracture has not been reached especially in the context of hardware failure. Closed methods, casting, percutaneous K-wires, external fixation, and reduction and internal fixation are all viable options.[5] Recent evidence suggests that open reduction and internal fixation is becoming the most commonly used for distal radius fracture and refractures, especially in the elderly.[6] Hospitals with specific Hand Surgery Centers have better outcomes and less complications due to expertise in appropriate equipment placement.[7] This is especially important in rural communities because elderly patients must often travel to one of the larger medical centers to receive care.

Specific considerations must be made in order to restore the anatomy of the radius. Length, inclination, and joint surface can all play a role in appropriate hardware selection. Volar plates are an ideal choice for high-impact fractures that are comminuted.[8] During surgery, image intensification with fluoroscopy is used to assess reduction and fixation. It is also useful to ensure articular congruency and screw placement. Successful placement of the volar plates is necessary before optimization and maintenance of the reduction can be performed with screws.[9] Postoperative immobilization maximizes recovery. Functional outcome is dependent on bony healing, which is often compromised in the elderly due to obesity and osteoporosis.[10] Although rare, complications can result from failed hardware. Tendon rupture can result from misplaced screws. Intra-articular placement of the plate warrants plate removal.[11] Nonunion can result from poor bony healing and in some cases may require grafting.[12]

In this report, we present a unique case of a 73-year-old female with a previously repaired distal radius fracture who was met with a motor vehicle accident,

which resulted in hardware failure. Motor vehicle collisions generate high-impact injuries. In the elderly, these injuries can be severe and lead to fractures due to increased levels of osteoporosis in this population. If preexisting hardware is present, refracture of a distal radius can compromise volar plate placement and alignment. Fortunately, hardware can sometimes be repaired through previous incisions and without the use of bone grafting. Depending on the extent of damage, new volar plates and screws may be necessary. We present a case of successful restoration of articular alignment following refracture and hardware failure due to trauma. We highlight the important considerations for treating wrist fractures in areas with an aging population.

CASE REPORT

A 73-year-old female with a previous history of an open reduction and internal fixation of a right distal radius fracture via a four-hole T plate 3 years prior was brought to the hospital following a motor vehicle collision. Her injuries included a grade 4 splenic laceration with active extravasation, closed head injury, and right radius and ulna fracture. X-ray examination showed the volar plate was angulated and still affixed to the distal radius. The angulation resulted in abnormal volar displacement of the radiocarpal joint relative to the distal ulna with a dorsal articular tilt of 46° (Figure 1). She was taken emergently for splenic artery embolization.

On posttrauma day 3, the patient was taken to the operating room for removal of deformed hardware and to undergo a new open reduction and internal fixation procedure. A longitudinal incision was made in the previous superficial scar with the standard volar Henry approach. Previous areas of screw placement had some ossification; therefore, a rongeur was used to smooth out the areas and help facilitate the placement of a new plate. Open reduction was performed with traction along the fingers in the radial direction and slight flexion and extension evaluated by fluoroscopy (Figure 2). Internal fixation was performed with a volar locking plate. Reduction maintenance and violation of the articular surfaces was verified, and placement of two additional screws in the radius shaft was performed with conformational fluoroscopy (Figure 3). Articular alignment was restored to a neutral volar tilt. The wound was irrigated, approximated, and closed. The patient was discharged and scheduled for follow-up with an orthopedic surgeon closer to home.

DISCUSSION

The dynamics of the damaged plate due to trauma in an elderly female in this case makes it unique in the literature in that the hardware required repair for adequate restoration of alignment. Because of the bending of the plate, it is difficult to know whether the plate itself complicated the injury or provided protection during the trauma. There is no lucency surrounding her hardware evident on plain films, and her hardware was well affixed to the bone at the time of hardware removal. This would suggest that nonunion was not involved in this situation, but nonunion should be considered in elderly patients due to increased risk of osteoporosis. The plate could have distributed the force load to stop further injury or created an unseen complication by holding the distal radial epiphysis in a dislocated state. The particular hardware chosen by her previous surgeon may have contributed to the failure as the plate was thin, and not a volar locking plate design, which contributes to a less stable repair in the elderly (Figure 4). Fortunately, the patient had an uncomplicated recovery. She was discharged and referred to a hand surgeon close to home for continued follow-up.

Open reduction and internal fixation with volar plating for treatment of distal radius fracture is becoming the emerging gold standard.[13] The most common complications of this treatment are extensor tendon or flexor tendon injury, flexor pollicis rupture, complex regional pain syndrome, and loss of reduction.[3] Hardware failure is a relatively rare occurrence.[4] Hardware failure due to trauma is extremely rare, but more common in the elderly due to motor vehicle collisions. In a retrospective review of 21 papers, it was found that almost 3% of volar plates required resultant surgery due to hardware failure, loosening, or at patient's request.[14] Case reports in the literature dealing with hardware failure put the blame on prolonged stresses from improper alignment making the hardware more likely to break upon impact.[12,15,16] The prolonged stress such as repetitive impact loading can lead to early breakage of volar plates and/or screws.[17] Often the failure is a result of poor selection of hardware during the initial surgery. Other factors that must be considered for the elderly include osteoporosis, obesity, and muscle weakness. Hardware failure in this reported case involved motor vehicle collision trauma, but the same principles must be considered for falls as well. Trauma provided high-impact acute stress that resulted in bending of the plate. Prolonged stress, which is more often seen in the elderly, can weaken the hardware to the point of breaking.

Figure 1. Right hand X-rays prior to operative management showing deformed hardware and displaced distal radius fracture.

Volar plating was initially used to give support to distal radius fixations in order to prevent hyperextension. They were designed to allow normal wrist mobilization early after surgery. Conventional volar plates were flat and contoured. These conventional plates required bone grafts for extra metaphyseal support, but the grafts do

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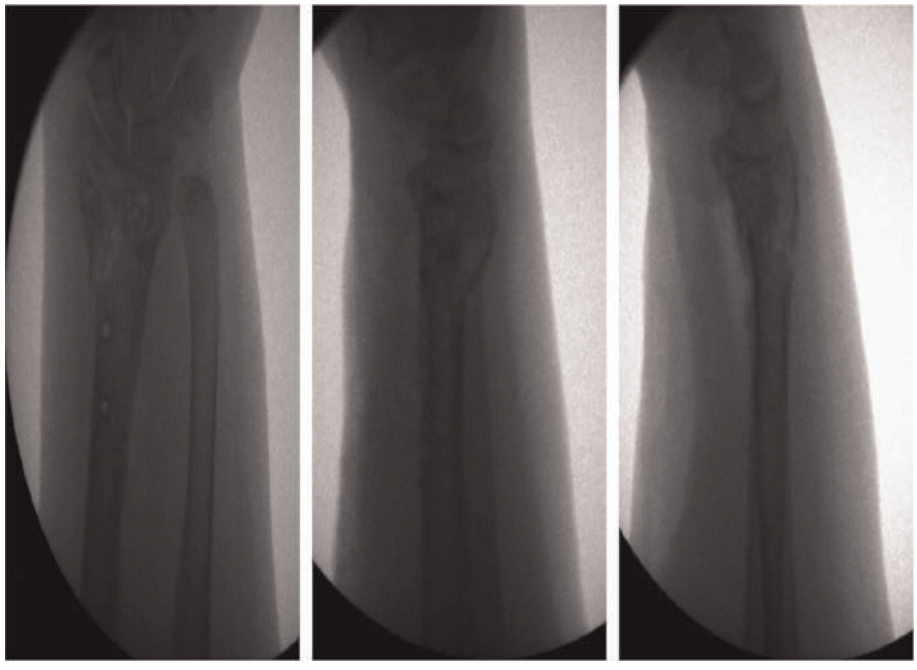

Figure 2. Intraoperative fluoroscopy imaging of right radius showing removal of previous hardware and visualization of screw holes with open reduction of the distal radius.

not always prevent nonunion in the elderly. The introduction of the fixed-angle locking plate allowed for rigid stabilizer without additional intervention or bone graft.[18] This treatment type has shown positive outcomes in both the 20- to 40-year-old age group and the greater than 60-year-old age group[19], especially well in the latter.

The use of volar locking plates results in excellent outcomes for most patients at extended time points

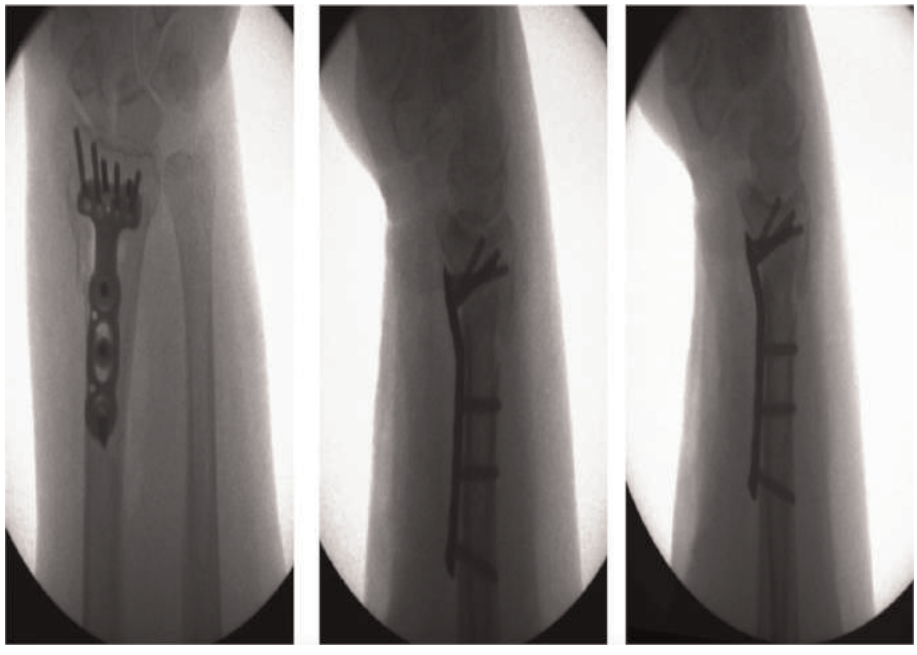

Figure 3. Intraoperative fluoroscopy showing placement of volar locking plate.

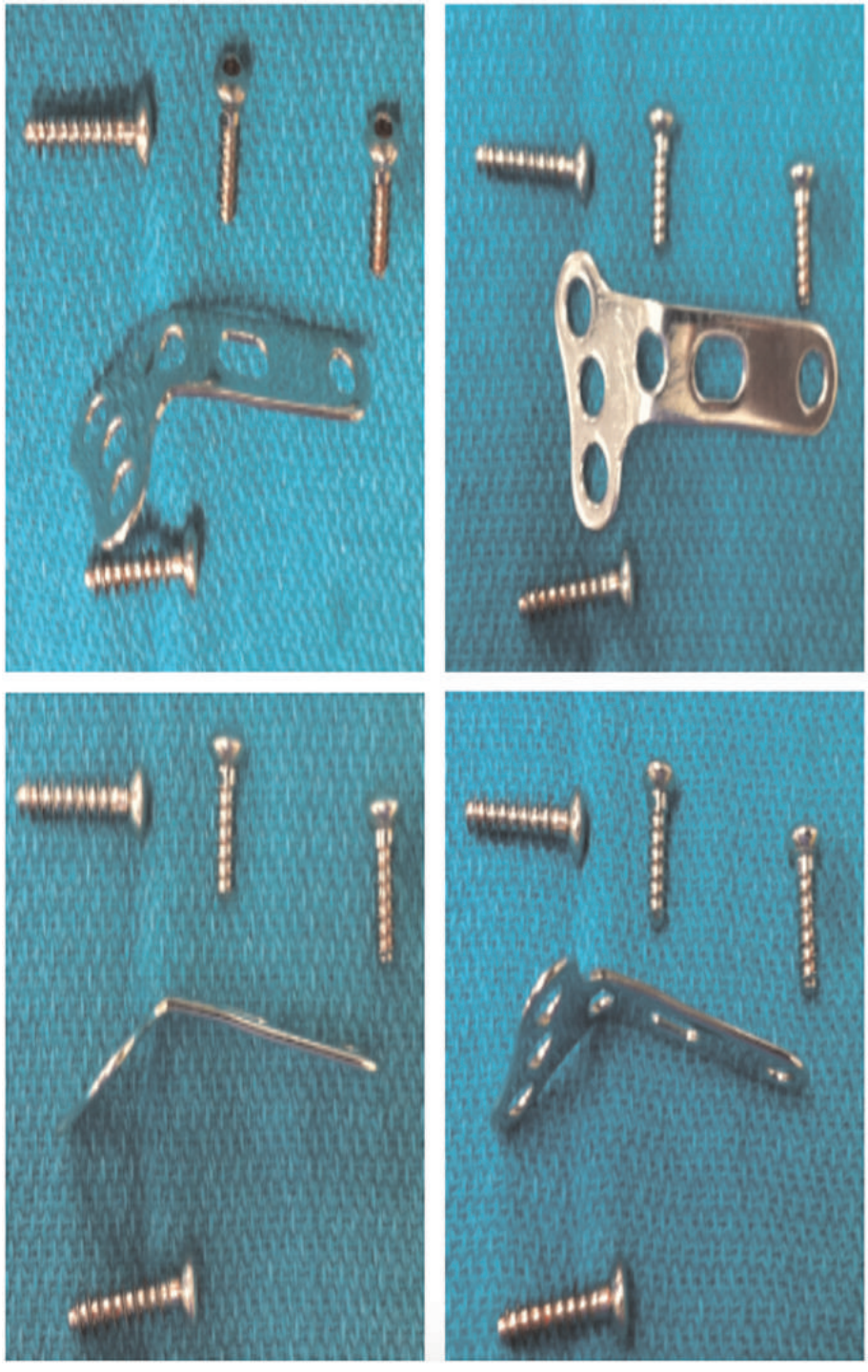

Figure 4. *Ex vivo*: removal of previous deformed volar plate and screws.

and leads to high patient satisfaction. However, a small number of patients do experience complications that can be debilitating, such as median nerve compression, nonunion, tendon irritation, and regional pain syndrome.[20] Two percent of patients experience some type of hardware failure. Dorsal low-profile plates have been used when volar locking plates fail.[21] Dorsal low-profile plates can reduce tendon irritation. Because the

hardware failure in the case of our patient was the result of trauma, volar plates were used to repair the distal radius fracture. Falls and trauma are the most common causes of distal radius fractures in the elderly, thereby making volar plates the ideal choice for this age group. Factors that may lead to higher risk of hardware failure include high-energy activities, such as motor vehicle collisions, and the complexity of injury. High-impact trauma accounted for the hardware overload in the aforementioned case. Distal radius fractures must be considered whenever caring for elderly patients following falls or motor vehicle collisions.

DISCLOSURE

All authors have nothing to disclose.

Conflict of interest and funding: The authors have not received any funding or benefits from industry or elsewhere to conduct this study.

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Aerococcus Viridans Infectious Endocarditis Complicated by Splenic Infarction†

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In this case report we discuss splenic infarction as a presentation for infectious endocarditis (IE). While not unheard of, splenic infarctions are usually incidental findings and are not usually used to diagnose IE. Since our patient was on hemodialysis, had AIDS and blood cultures tested positive for Aerococcus viridans *and* Streptococcus parasanguis*, we propose that atypical presentations of IE should be considered in immunocompromised patients.*

Keywords: *splenic infarct; infectious endocarditis; aerococcus viridans; HIV; immunocompromised; hemodialysis*

INTRODUCTION

Infectious endocarditis (IE) is an infection of the endocardium which can present with various vascular phenomena ranging from major arterial emboli, intracranial hemorrhage, septic pulmonary infarcts, and Janeway lesions. Vascular embolization is present in up to 22 to 50% of cases of IE.[1] The risk of embolization increases with vegetations > 1 cm.[2] In our case report, we describe a 40-year-old HIV-positive female on hemodialysis who presented with IE manifesting as multiple splenic infarctions in the absence of vegetations detected by transthoracic echocardiogram (TTE) or transesophageal echocardiogram (TEE). This raises the possibility of unusual vascular manifestations of IE in immunocompromised patients.

CASE REPORT

Our patient is a 40-year-old female with a past medical history significant for HIV with a CD4 count of 58, end-stage renal disease on hemodialysis with AV fistula, chronic pancreatitis, seizures (controlled with levetiracetam), and type 2 diabetes mellitus who presented with a 2-day history of abdominal pain radiating to the back. She also had diarrhea, diminished appetite, nausea, vomiting, fever, chills, chest discomfort, and generalized malaise. On presentation her vitals were: Blood Pressure: 188/127 mm Hg; Temperature: 38°C (100.4°F); Heart Rate: 114; Respiratory Rate: 16; SpO2: 98% (room air); Height: 160 cm (5′ 3″); and Weight 54 kg (119 lb 0.8 oz). On initial physical exam, the patient was in mild distress; no skin lesions were noted; she had diffuse crackles auscultated in bilateral lung fields; no murmurs or rubs were heard on initial cardiology exam; she had tenderness to palpation in the epigastric region; and abdomen was soft, nondistended, and bowel sounds were present. She was admitted for chronic pancreatitis exacerbation. Abdominal CT was performed, blood cultures collected, and the patient was empirically treated with vancomycin and piperacillin/tazobactam.

Blood cultures taken on admission came back positive 3 days later for *S. parasanguis* and *A. viridans*. Five days after admission, a new grade III/VI holosystolic murmur at the mitral focus that exacerbated on expiration was noted on cardiovascular examination. Patient also had a (+) rheumatoid factor during the admission, intermittent fevers, and new splenic infarct found on abdominal CT (Fig. 1). TTE and TEE 4 days after admission did not reveal any valvular vegetation or abscess. Repeat blood cultures also confirmed infection with *S. parasanguis* and *A. viridans*. The patient fulfilled Duke's criteria with two major criteria of new valvular regurgitation, blood cultures positive for *S. parasanguis* (part of the *S. viridans* group), and three minor criteria of vascular phenomena of splenic infarction, positive rheumatoid

†None of the authors have anything to disclose.

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Figure 1. Abdominal CT of the patient. A 22.1 mm × 10.7 mm hypodense area is noted the posteromedial spleen near the rib – a new finding compared to her previous CT. A small part of the pancreas is visible in this image, with calcifications indicative of her chronic pancreatitis.

factor, and fever during her stay. She then began treatment for infective endocarditis by continuing the IV vancomycin with gentamicin for 6 weeks. The piperacillin/tazobactam was discontinued. The patient's hospital course was complicated by uncontrolled abdominal pain and social work placement; she was eventually discharged on hospital day 17 and within the next 30 days, she was readmitted twice for unrelated causes. She eventually finished her 6 weeks of vancomycin and gentamicin during the third hospital admission. Her blood cultures at 7 days from the initial positive blood culture were consistently negative throughout her current and future hospitalization.

DISCUSSION

Vegetations in IE are composed of fibrin, platelets, microcolonies of microorganisms, and inflammatory cells.[3] These vegetations can then break off and embolize, leading to infection and infarction in distant sites. Embolization is common in IE with the lungs, central nervous system, bowel, and spleen being the most common sites for embolization. Mitral valve vegetations have the highest chance of embolizing, followed by aortic and right-sided vegetations. The infectious agent may also have a role in determining the risk of embolization, with staphylococcal and fungal IE having higher rates.[4]

In this case, the HIV-positive patient experienced multiple splenic infarcts without evidence of vegetation on TTE or TEE. Complicating her immunocompromised status was our patient's end-stage renal disease. Hemodialysis has been shown to significantly increase the risk of IE, with studies showing a relative risk of 16.9 of IE compared to the general population.[5] *Staphylococcus aureus* is the most common pathogen implicated in patients on chronic hemodialysis. Our patient had a polymicrobial IE with blood cultures that tested positive for a *S. parasanguis* and *A. viridans*. While *S. parasanguis* is a known cause of subacute bacterial endocarditis, *A. viridans* is a rare organism and concomitant coinfection suggests a nosocomial etiology. A study describing 11 cases of *A. viridans* IE showed a predisposition to embolization, with every case positive for vegetations.[6] Another case report postulated that immunocompromised status was a risk factor for *A. viridans* IE.[7]

With our patient's uncommon presentation of splenic infarctions without vegetations as well as a polymicrobial IE with a rare organism, we posit that her immunocompromised status with chronic hemodialysis could have contributed to her presentation. Since our patient was started on empiric antibiotics, there is a possibility that our patient's vegetation could have embolized and caused her splenic infarctions before TTE and TEE were done.[4] There could have also been a false negative result from the echocardiography, but this might be less likely because of the large sizes of vegetations described from previous cases of *A. viridans* IE.[6] While our patient fulfilled the Duke's criteria for IE, her uncommon presentation of splenic infarctions delayed her diagnosis and treatment until after her blood cultures returned positive and her new heart murmur was appreciated. We recommend that a lower threshold to diagnosis IE in immunocompromised patients with risk factors such as hemodialysis be used in order to facilitate effective treatment.

Conflict of interest and funding: The authors have not received any funding or benefits from industry or elsewhere to conduct this study.

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Unexplained Bleeding: Case Report of Glanzmann Thrombasthenia

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Background: *Glanzmann thrombasthenia (GT) is a rare inherited genetic platelet disorder characterized by a qualitative or quantitative mutation in GPIIb/IIIa receptor, which results in defective platelet aggregation and diminished clot retraction.*

The Case: *A 19-year-old female of Arab descent presented to the emergency department with severe menorrhagia. Examination revealed an ill-looking, pale patient with generalized fatigue of a week's duration.*

Conclusion: *Acquired platelet disorders are more frequently encountered in practice than inherited ones, usually due to medical therapy or an underlying medical condition. GT, previously known as hereditary hemorrhagic thrombasthenia, is an autosomal recessive disorder that is often disregarded as it has many clinical and laboratory findings similar to some acquired platelet disorders.*

Keywords: *Glanzmann thrombasthenia; inherited platelet disorder; the disorder of hemostasis*

INTRODUCTION

Platelets have many roles in physiological processes in the human body, including hemostasis, in which adhesive proteins, such as collagen and thromboplastin, released by the damaged endothelium bind and aggregate platelets, leading to thrombus formation with subsequent activation of coagulation pathways. Any disruption of this pathway, acquired or inherited, will result in bleeding.

Glanzmann thrombasthenia (GT), previously known as hereditary hemorrhagic thrombasthenia, is a rare autosomal recessive disorder of GPIIb/IIIa surface receptor that was first described in 1918. The exact number of affected cases is unknown; however, it is estimated that one per million people does have GT, with women being affected more than men (60 and 40%, respectively). GT was noticed to be more common in certain ethnic groups such as Arabs and French gypsies.[1,2]

GPIIb/IIIa is a heterodimeric transmembrane cell receptor that consists of two subunits, an αIIb and a smaller β3, which are linked non-covalently.[3] This receptor binds fibrinogen, vitronectin, and fibronectin, which are necessary for platelet aggregation; also, it regulates cell migration. Deletions, insertions, and frameshift mutations in this receptor have been reported to cause GT.[4] Based on the expression and functionality of the receptor, GT is divided into three types, depending on the level of GPIIb/IIIa present. However, it is important to note that the clinical severity of GT does not correlate with subtypes as it was noted by Fiore et al. that phenotypic bleeding is more influenced by a mutation in ITGB3 gene.[5] The subtypes include:

- *Type 1:* <5% of normal GPIIb/IIIa levels (severe).
- *Type 2:* 10–20% of normal GPIIb/IIIa levels (moderate).
- *Type 3:* Normal GPIIb/IIIa levels, but functionally inactive (variant).

THE CASE

A 19-year-old female of Arab descent presented to the emergency department with severe menorrhagia with generalized fatigue for 10 days. The patient denied any bleeding in between cycles but complained of frequent epistaxis; an initial diagnosis of von Willebrand disease was made but ruled out soon after due to normal coagulation parameters. Examination revealed a pale, ill-looking female with signs of anemia including conjunctival pallor and tachycardia.

The patient was admitted to female medical ward, and initial lab results showed RBCs: 1.70X1012/L, Hb: 4.20 g/dL, Hct: 14.40%, MCV: 84.50fL, MCH: 24.70 pg, MCHC: 29.30 g/dL, RDW: 21.60%, platelets: 156.00 $\times$ 10^3/mcL, and normal coagulation profile, with prolonged bleeding time. A thorough history was taken from the patient, which revealed that the patient had visited a gynecology clinic 3 years ago with complaint of late menarche, similar issue was noted in the family, and had an extensive hormonal and biomedical examination, all of which came out negative for a cause of late menarche. Also, the patient's history revealed multiple previous episodes of epistaxis that was controlled by simple measures such as nasal compression; a positive family history of GT was noted. Flow cytometry was performed, which showed decreased levels of CD41 and CD61. Thus, diagnosis of GT was made. The patient was treated with a blood transfusion and then discharged.

DISCUSSION

GT diagnosis is often challenging and overlooked. GT shares many clinical and laboratory findings with other more common acquired bleeding disorders. GT should be considered as a differential diagnosis in patients with a history of severe bleeding following minor trauma or unprovoked bleeding. The family history of consanguinity or other affected members, such as in this case, plays a fundamental role in GT diagnosis.

The majority of GT-affected patients will be diagnosed in the first 5 years of their lives due to recurring gingival bleeding or epistaxis as the most common presentations.[1] In males, excessive bleeding after circumcision has been reported as the first sign of the disease. However, females could be diagnosed later in life when menses ensue. Although fatal bleeding can happen to both genders at any stage in life, it usually tends to decrease in incidence as patients age.[6]

Menorrhagia is a critical hemorrhagic problem. Bleeding at menarche represents a particular risk and is sometimes severe enough to require transfusion. This is consistent with the prolonged proliferative estrogen stimulation of the initial anovulatory cycles, which can cause greater and more prolonged bleeding with the first menstrual periods in normal adolescents. Control of menstrual bleeding is a major problem. Severe menorrhagia, usually associated with an excessively proliferative endometrium caused by estrogen dominance, can be effectively treated by a high dose of 19-norprogesterone. Maintenance treatment with birth control pills, such as a combination of norethindrone acetate and ethinyl estradiol, should be started.[6]

Light transmission aggregometry is the gold standard for the diagnosis of GT, but it is a time-consuming procedure that is done in highly specialized centers. Other diagnostic procedures include flow cytometry, which denotes the presence or absence of CD61, CD41 and GPIIb/IIIa, and platelet function analyzer.[4] Finally, family history plays a significant role in diagnosing GT.[7]

Up to this point, medical therapy is the only option most GT patients have. However, most patients do not require treatment on a regular basis. The current treatment guideline for GT bleeding episodes is to use local measures, such as nose compression in case of epistaxis, alone or in addition to anti-fibrinolytic remedy.[3] If bleeding continues, platelet transfusion and Recombinant Activated Factor VII administration are advised.

Patient education and awareness play an important role in GT management, as almost all patients will receive a blood transfusion at least once in their lifetime.[4] Accordingly, all GT patients are advised to have hepatitis B vaccination and avoid contact sports. Also, patients should avoid the use of aspirin or non-steroidal anti-inflammatory drugs.

The early workup with GT patients led to the discovery of some of the currently known potent antithrombotics, when a patient with GT who developed a unique powerful antibody against GPIIb/IIIa following multiple transfusions appeared to be a potential source of a therapeutic agent. This antibody was used to make a murine humanized monoclonal antibody (abciximab), was introduced into clinical practice showing significant reduction in the combined endpoint of acute myocardial infarction, need for emergency coronary artery bypass grafting and mortality in patients undergoing percutaneous coronary intervention.[7]

TAKE-HOME POINTS

1. Suspicion of GT should be raised in cases of family bleeding after a minor trauma in males and females.
2. Patient education is a cornerstone in the management of GT as bleeding episodes can occur at any time.

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Scrotal Rupture in a Premature Neonate with Cystic Fibrosis as a Consequence of Meconium Periorchitis

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Neonatal meconium periorchitis is a rare condition, with less than 60 cases described in the literature. Of the reported cases, only one describes the complication of a congenital rupture of the scrotum. We present a case of a Hispanic preterm neonate who was diagnosed with cystic fibrosis after scrotal rupture secondary to meconium periorchitis. The neonate was taken to the operating room for exploratory laparotomy and scrotal exploration. No calcification was noted, and the patient's left scrotum was surgically packed as well as a colostomy was created. The surgery proved successful, and the patient was discharged home on day of life 79. This case of a neonate presenting with meconium periorchitis and scrotal rupture notes the varying degree of initial presentations for cystic fibrosis in a neonate. Successful outcomes for neonates presenting with a ruptured scrotum depend on early clinical assessment.

Keywords: *neonate; meconium peritonitis; meconium periorchitis; cystic fibrosis; scrotal rupture; premature.*

INTRODUCTION

Neonatal meconium periorchitis (MPO) is a rare condition, with less than 60 cases described in the literature. It is characterized by an in utero intestinal perforation leading to an extravasation of bowel contents into the scrotum.[1,2] Neonates with MPO typically present with a soft testicular mass or discolored and swollen scrotal area.[3] Of the reported cases, only one describes the complication of a congenital rupture of the scrotum.[4] We present a case of a preterm Hispanic neonate who was diagnosed with cystic fibrosis after scrotal rupture secondary to MPO.

CASE REPORT

A twin Hispanic male neonate was born at 31 weeks with Apgar scores of 3 and 8 at 1 and 5 min, respectively, and with a birth weight of 1,885 g. Pregnancy was complicated by polyhydramnios, fetal ascites, and poor prenatal care, and the neonate was delivered via Caesarean section for twin-to-twin transfusion syndrome (our patient was the recipient twin). Resuscitation was unremarkable; however, it was noted that the neonate had a grossly distended abdomen and an enlarged left scrotum. A thick, dark discharge, presumed to be meconium, was also found to be exuding from the left scrotum (Figure 1).

In the neonatal intensive care unit, an abdominal radiograph did not demonstrate calcifications, but an ultrasound showed free fluid in the abdomen containing floating debris that extended into the scrotum. A scrotal ultrasound showed a diffuse echogenic mass within the left scrotal sac.

The neonate was emergently taken to the operating room (OR) for exploratory laparotomy and left scrotal exploration. In the OR, surgeons confirmed an in utero perforation of the transverse colon with extravasation of meconium through the scrotal sac (Figure 2). The surgeons resected the involved bowel and created a colostomy, while the perforated left scrotum was surgically packed. Daily scrotal packing with ribbon gauze impregnated with Vaseline was performed by the surgical team to facilitate the growth of granulation tissue.

The patient remained on mechanical ventilator support for 14 days and was then transitioned to nasal cannula for 19 days. The neonate returned to the OR on day of life (DOL) 17 for colostomy takedown, and he reached full enteral feeds on DOL 20. There were no complications from the surgery; the neonate healed appropriately and was discharged home on DOL 79. DNA testing established diagnosis of cystic fibrosis in both neonates (homozygous F 508 mutation).

There are no prior publications with any overlapping information, including studies and patients. The manuscript has not been and will not be submitted to any other journal while it is under consideration by the *Medical Student Research Journal*.

Figure 1. Initial appearance of patient's scrotum.

The neonate had a follow-up at 4 months in clinic with minimal scarring and no drainage.

DISCUSSION/REVIEW OF LITERATURE

MPO is an unusual complication of meconium peritonitis. Since the discovery of meconium peritonitis in 1953, the phenomenon of MPO has been described in fewer than 60 cases in the literature.[5,6] Our case is exceptionally rare as there has only been one documented patient over the past two decades who presented with extravasation of bowel contents through the scrotum.[4] There have only been three reported cases of MPO in patients with cystic fibrosis, and none of these cases has presented with congenital scrotal rupture.[5–8]

The clinical presentation of MPO is variable, but typically it presents in utero or at birth with scrotal swelling due to the presence of meconium. The displaced meconium initiates an inflammatory reaction that may begin within 24 h and results in fibrosis and calcifications.[6] Forms of peritoneal calcifications include localized and generalized fibroadhesive type. Localized fibroadhesive type is the most common form, resulting in linear peritoneal calcification, while the generalized fibroadhesive type is associated with ascites.[9] Scrotal calcifications, with or without these peritoneal calcifications, are pathognomonic findings on perinatal ultrasonography.[8]

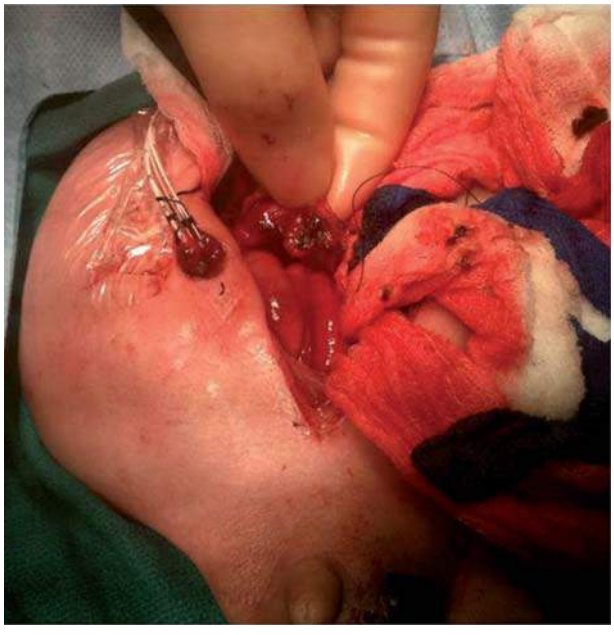

Figure 2. Intrauterine perforation of transverse colon.

If MPO is not clinically apparent at birth, it will present in a milder form later in the neonatal period often resembling hydroceles, which calcify with time. These patients have been noted to return to their primary care provider within the first 2 years of life with a palpable scrotal mass.[9] This delayed presentation allows time for the meconium in the scrotal sac to calcify and become adhered to the testicle forming a hard, nodular, and solid mass. Previous case reports demonstrate that this clinical finding makes it difficult to determine if the mass is intra- or extra-testicular, often leading to surgical exploration.[6] Table 1 shows a comparison of MPO cases, their presentation, management of the scrotal mass, and their outcome. While most of the cases are discovered during prenatal ultrasound, some, including our case, are detected at birth or after. Most of the cases resulted in surgical removal of the mass, and only two patients were found to have cystic fibrosis.

The successful outcome of our patient was due to several factors, including early assessment of clinical presentation, no testicular involvement, and no additional surgery required for repair of the ruptured scrotum. At the time of the surgery, an ultrasound was performed, which showed bilateral descended testicles, normal epididymis, and good perfusion, indicating a lack of testicular involvement. Testicular involvement can lead to complications not immediately measurable, including testicular atrophy, infertility, or torsion. Additional surgery could have resulted in further complications including infection, adhesions, or excessive bleeding. With scrotal rupture present, the bowel perforation was able to be identified and repaired while sparing testicular surgery. Previous literature has noted that finding a source for the scrotal mass can lessen confusion for a scrotal tumor leading to unnecessary orchiectomy.[10]

CONCLUSION

When MPO with congenital rupture of the scrotum is found, it is important to consider cystic fibrosis as a cause. These findings are relevant to all neonates that

Table 1. Comparison of case presentations of meconium periorchitis.

Year	Author	Age	Presentation	Management	Outcome
2016	Bedgood et al.	31 weeks gestation	Scrotal rupture	Surgery at presentation	Cystic fibrosis
2013	Alanbuki et al.	2 months post term	Scrotal mass	Surgery at presentation	Uneventful
2009	Regev et al.	39 weeks gestation	Hydrocele	Surgery at 5 months postterm	Uneventful
2009	Regev et al.	36 weeks gestation	Hydrocele	Conservative	Uneventful
2003	Sofeman et al.	37 weeks gestation	Hydrocele	Conservative	Cystic fibrosis

present with atypical features of cystic fibrosis, such as scrotal rupture, in order to expedite their diagnosis and ensure proper follow-up care. This identification may spare the need for unnecessary orchiectomy and lead to more successful outcomes.

LEARNING POINTS

- MPO with congenital rupture of the scrotum can be the initial presentation of cystic fibrosis in neonates.
- MPO is an in utero intestinal perforation leading to extravasation of bowel contents into the scrotal sac.
- Recognizing congenital rupture of the scrotum can help identify bowel perforation that may be treated surgically based on patient factors with colostomy and extravasation of the meconium through the scrotal sac.

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Systematic review of the accuracy of magnetic resonance imaging in the diagnosis of acute appendicitis in children: Comparison with computed tomography†

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Objective: *Computed tomography (CT) has emerged as the gold standard test for the evaluation of suspected appendicitis in pediatric patients. It has been shown to have excellent accuracy and to decrease negative appendectomy rates. However, CT scans expose patients to ionizing radiation, which is of especially high concern in children. Magnetic resonance imaging (MRI) is a potential alternative that could be used to evaluate children while eliminating exposure to radiation. This systematic review tests the hypothesis that the sensitivity and specificity of MRI are not inferior to that of CT in the evaluation of suspected appendicitis in children.*

Methods: *A search of the Medline database was conducted to identify articles that used MRI to evaluate children with suspected appendicitis. Articles that focused on pediatric subjects and reported sensitivity and specificity of MRI in these subjects were included. Data for the calculation of sensitivity, specificity, and 95% confidence intervals for each were extracted from each study included. Pooled data for sensitivity and specificity of MRI were calculated and tested for significance compared to sensitivity and specificity of CT using Fisher's exact test.*

Results: *Nine studies were found to be relevant to the question posed by this systematic review and met the inclusion criteria. The pooled sensitivity and specificity of MRI for the diagnosis of appendicitis were 0.96 (95% CI: 0.94–0.98) and 0.97 (95% CI: 0.96–0.98) as opposed to values of 0.94 (95% CI: 0.92–0.97) and 0.95 (95% CI: 0.94–0.97) for CT. The difference between MRI and CT was not statistically significant for sensitivity (*p*=0.11) or specificity (*p*=0.06) in the evaluation of suspected appendicitis in children.*

Conclusions: *In children with suspected appendicitis, the sensitivity and specificity of MRI are comparable to those of CT in terms of sensitivity and specificity. MRI is a viable choice for imaging in these patients and limits exposure to radiation.*

Keywords: *appendicitis; diagnostic Iimaging; sensitivity; specificity; children*

INTRODUCTION

Appendicitis is the most common indication for emergent abdominal surgery in patients under the age of 18 years, with more than 70,000 such patients diagnosed with appendicitis each year in the United States.[1,2] A missed or delayed diagnosis often results in perforation of the appendix and deterioration of the patient's condition. On the contrary, a false diagnosis of acute appendicitis can lead to unnecessary surgical interventions. In a study of 475,651 appendectomy cases in the United States between 1998 and 2007, the negative appendectomy rate was found to be 11.83%.[3] As an attempt to minimize the incidence of such adverse events and as a result of the high level of variation in signs of appendicitis in pediatric patients, the vast majority of children undergo preoperative imaging prior to appendectomy.[4] The use of diagnostic cross-sectional imaging in the evaluation of patients with suspected acute appendicitis has increased dramatically over the past decades, especially the use of computed tomography (CT), which has emerged as the current gold standard test. The widespread use of CT in the diagnosis of appendicitis is largely due to its being widely available and relatively simple to operate compared to other cross-sectional imaging modalities such as magnetic resonance imaging (MRI).[5] The high sensitivity and specificity of CT in diagnosing appendicitis is well documented in both children and adults, and its use in preoperative situations has been found to be correlated with a significant decrease in the negative appendectomy rate.[6–8] The largest meta-analysis to date on the accuracy of CT in the diagnosis of acute

†The author does not have anything to disclose.

appendicitis analyzed 26 studies including 9,356 children, concluding that CT has a sensitivity of 0.94 (95% CI: 0.92–0.97) and specificity of 0.95 (95% CI: 0.94–0.97) for evaluation of pediatric patients.[9] However, a single abdominal CT scan exposes patients to as much ionizing radiation as over 50 conventional x-rays of the abdomen. Several studies have found that people that underwent CT as children have a significantly elevated risk of malignancy later in life.[10–12] Furthermore, the intravenous contrast agent commonly administered during CT is associated with a small but significant risk of allergic reactions and/or nephropathy.[13,14] As a result, more institutions are utilizing ultrasonography for the diagnosis of appendicitis, and it has become the first-line diagnostic modality in pregnant and pediatric patients in most facilities. Ultrasonography is almost universally available, uses no ionizing radiation, and has lower associated costs, but it is operator dependent, resulting in highly variable sensitivity findings.[9,15–17] As a result, CT remains the most commonly used preoperative imaging modality in children undergoing appendectomy.[4] A strategy involving the use of ultrasonography as the first-line test for acute appendicitis and CT for use only in cases with indeterminate ultrasound has recently been recommended, and has been shown to be highly accurate.[18,19]

MRI is another viable modality for imaging the abdomen in pediatric patients, but it currently plays only a minor role in the evaluation of patients with suspected acute appendicitis. This is largely due to high associated costs, limited availability, and the high level of operator expertise required. In addition, MRI requires patients to lie still for extended periods of time, which may be of particular concern when evaluating small children. MRI already has an established role in imaging of pregnant women with suspected acute appendicitis and inconclusive ultrasound findings, but the American College of Radiology continues to list MRI as less appropriate than CT for the evaluation of both children and nonpregnant adults with suspected acute appendicitis, citing a lack of evidence of the diagnostic accuracy of MRI in the general population.[20] However, MRI is beginning to emerge as an alternative modality for the evaluation of patients with abdominopelvic pain, particularly as it becomes more readily available in the emergency setting and more rapid imaging sequences are developed.[21] MRI could be a particularly attractive option in the evaluation of pediatric patients with suspected appendicitis, as it does not involve exposure to ionizing radiation. Recent small-scale studies on the accuracy of MRI in the diagnosis of acute appendicitis show sensitivity and specificity similar to that of CT, but many of these studies cite a need for larger scale research to confirm these results.[22] If MRI were found to have comparable accuracy to that of CT in pediatric patients, clinicians could avoid exposing children to damaging ionizing radiation, as well as prevent the development of radiation-induced malignancies without sacrificing diagnostic efficacy. The purpose of this review is to research the relevant literature on the accuracy of MRI in diagnosing acute appendicitis in children in order to analyze the hypothesis that the accuracy of MRI in the diagnosis of acute appendicitis in pediatric patients is not inferior to that of CT.

METHODS

For this review, a search of the Medline database for literature regarding the accuracy of MRI in the evaluation of suspected appendicitis in children was conducted using the 'advanced search' feature and the medical subject headings (MeSH) database. Only studies published within the past 10 years were included in this review. To be included, studies had to focus on pediatric patients under age 18 and include sensitivity and specificity values for MRI and 95% confidence intervals for each, or else provide sufficient data to permit the calculation of these values. Studies that included pregnant patients were excluded. One study that duplicated data by basing multiple data points on each MR image by including multiple interpretations was also excluded.

Each study considered for inclusion in this review was analyzed for quality and content. Several elements were evaluated when reviewing an article for quality and likelihood of bias. This included methods for subject selection, particularly how potential subjects were chosen for further imaging. Another important element that was evaluated was the heterogeneity of imaging protocols used in each study, including the MRI sequences used and whether gadolinium-based contrast was used. Some other considerations were the reference standard and index test used, completeness of subject follow-up, and protocols for radiographic diagnosis of appendicitis. For reference, each study in this review was also assigned an evidence level of 1–4 based on study design, with level 1 being of the highest value. Randomized controlled trials were considered level 1. Nonrandomized controlled trials were considered level 2. Observational studies with controls were considered level 3, while observational studies without controls were considered level 4.

Sensitivity and specificity for MRI in the evaluation of suspected appendicitis in each study was calculated, along with 95% confidence intervals for both. An evidence table and forest plot were constructed containing the results of each study included in this review. In order to compare the sensitivity and specificity of MRI to that of CT in the diagnosis of acute appendicitis, the MRI data from all included studies were pooled and compared to sensitivity and specificity results from the largest meta-analysis on the accuracy of CT in diagnosing acute appendicitis to date.[9] A test for significance was conducted using Fisher's exact test. An analysis was also carried out using Fisher's exact test to compare sensitivity and specificity of MRI in studies in which MRI was used only after an indeterminate ultrasound versus in studies in which MRI was used as the primary imaging modality. In both analyses, a two-tailed p-value of <0.05 indicated significance.

RESULTS

A preliminary search for 'appendicitis/diagnosis' [MeSH] OR 'appendicitis/radiography' [MeSH] returned 8,335 results. Adding the term 'child' [MeSH] to the search narrowed the results to 2,624 articles. The addition of the term 'magnetic resonance imaging' [MeSH] further narrowed the results down to 37 articles. Exclusion of all studies published more than 10 years ago decreased the number of results to 30. These 30 articles were closely evaluated by the author to determine their level of relevance to the hypothesis tested in this review, as well as for whether or not the inclusion and exclusion criteria were met. Nine studies were found to meet all requirements and be relevant to the hypothesis tested by this review. Among these, three are prospective studies, six are retrospective studies, and one is a comparative study. Two studies directly compare the accuracy of MRI to that of CT in diagnosing appendicitis in children, while the other eight report sensitivity and specificity of only MRI. Between them, the 10 studies included in this review analyzed 1,524 pediatric patients.[23–32]

Evaluation of Use of MRI Following Indeterminate Ultrasound Results

Dillman et al[23] conducted a retrospective analysis of the charts of 161 pediatric patients who underwent MRI or CT for suspected appendicitis after an indeterminate ultrasound. Of these, 103 subjects underwent MRI and 58 underwent CT. Sensitivity and specificity of MRI and CT in the diagnosis of appendicitis in the study sample were calculated, and the Fisher exact test was used to compare these values for MRI versus CT, with $p<0.05$ indicating significance. MRI correctly identified 17/18 subjects with confirmed appendicitis (Sensitivity=0.944; 95% CI: 0.727–0.999) and 85/85 of the remaining subjects who did not have appendicitis (Specificity=1.00; 95% CI: 0.958–1.00). CT correctly identified 11/11 patients with confirmed appendicitis (Sensitivity=1.00; 95% CI: 0.715–1.00) and 46/47 of subjects without appendicitis (Specificity=0.979; 95% CI: 0.887–1.00). Using the Fisher exact test, the difference between the sensitivities ($p=1.00$) and specificities ($p=0.36$) showed no statistically significant difference.[23]

Thieme et al[24] prospectively studied a cohort of 104 consecutive pediatric patients with clinically suspected appendicitis, all of whom underwent abdominal ultrasound followed by MRI. This study evaluated three diagnostic strategies: ultrasound alone, ultrasound followed by MRI if the result is equivocal, and MRI alone. Sensitivity and specificity were calculated for each strategy. The authors used the McNemar test statistic to compare each method, with $p<0.05$ indicating significance. Ultrasound alone correctly identified 44/58 patients with appendicitis (Sensitivity=0.76; 95% CI: 0.63–0.85) and 41 of 46 patients without appendicitis (Specificity=0.89; 95% CI: 0.76–0.96). The conditional MRI strategy correctly identified 58/58 patients with appendicitis (Sensitivity=1.0; 95% CI: 0.92–1.0) and 37/46 patients without appendicitis (Specificity=0.80; 95% CI: 0.66–0.90). MRI alone correctly identified 58/58 patients with appendicitis (Sensitivity=1.0; 95% CI: 0.92–1.0) and 41/46 patients without appendicitis (Specificity=0.89; 95% CI: 0.76–0.96). The sensitivities of conditional MRI and MRI alone were found to be significantly higher than that of ultrasound alone ($p<0.001$), while there was no significant difference in specificity between any of the three strategies ($p=0.13$ for ultrasound alone, 0.13 for conditional MRI, 1.00 for MRI alone).[24]

Herliczek, Swenson, and Mayo-Smith[25] conducted a retrospective analysis of a cohort of 60 consecutive pediatric patients that underwent MRI for suspected appendicitis following an inconclusive ultrasound. The accuracy of MRI in this context was evaluated by calculating sensitivity and specificity for MRI in the diagnosis of acute appendicitis in the sample after an inconclusive ultrasound examination. Two MRI readers correctly identified 10/10 subjects with confirmed appendicitis

(Sensitivity=1.00; 95% CI: 0.69–1.00) and 48/50 of those without appendicitis (Specificity=0.96; 95% CI: 0.86–1.00).[25]

A retrospective analysis conducted by Rosines et al[26] evaluated 49 pediatric patients that underwent MRI for suspected acute appendicitis following an indeterminate ultrasound. MRI both with and without contrast was used for each patient. MR images were interpreted by a team of five radiologists, who came to a consensus on each image. Accuracy of MRI was evaluated by calculating the sensitivity and specificity for MRI in the diagnosis of acute appendicitis in this sample after indeterminate ultrasound. MRI correctly identified 15/16 subjects with appendicitis (Sensitivity=0.94; 95% CI: 0.70–1.00) and 33/33 of those without appendicitis (Specificity=1.00; 95% CI: 0.89–1.00).[26]

Studies that Evaluate Use of MRI Alone

Kulaylat et al[27] retrospectively analyzed a cohort of 655 pediatric patients that underwent imaging for suspected appendicitis. A total of 510 of these subjects were evaluated by MRI, and images were evaluated independently by three reviewers. Sensitivity and specificity of MRI were calculated to assess diagnostic accuracy. MRI correctly identified 122/126 subjects with confirmed appendicitis (Sensitivity=0.968; 95% CI: 0.921–0.991) and 374/384 of those without appendicitis (Specificity=0.974; 95% CI: 0.953–0.987).[27]

Moore et al[28] completed a retrospective study analyzing the accuracy of MRI 208 pediatric patients with suspected acute appendicitis. MR images were interpreted by one of six pediatric radiologists, and values for sensitivity and specificity of MRI were calculated. MRI correctly identified 40/41 subjects with confirmed appendicitis (Sensitivity=0.976; 95% CI: 0.871–0.999) and 162/167 subjects without appendicitis (Specificity= 0.970; 95% CI: 0.932–0.990).[28]

Orth et al.[29] conducted a prospective study of 81 pediatric patients that were to undergo an ultrasound examination for suspected acute appendicitis and underwent MRI. A total of 453 subjects met the inclusion criteria for the study but consent could not be obtained for 372 of these. The remaining 81 subjects included by the authors underwent both abdominal ultrasound and MRI. Accuracy of MRI was evaluated by calculating its sensitivity and specificity in this sample. These values were calculated twice: once with equivocal results designated as positive, and once with equivocal cases designated as negative. MRI correctly identified 28/30 subjects with confirmed appendicitis (Sensitivity=0.933; 95% CI: 0.779–0.992), and 50/51 subjects without appendicitis (Specificity=0.980; 95% CI: 0.896–1.00). None of the MR studies were found to be equivocal for acute appendicitis.[29]

Bayraktutan et al[30] conducted a prospective study of 47 consecutive pediatric patients with clinically diagnosed acute appendicitis or an appendix that could not be visualized on ultrasonography. A total of 31 patients underwent abdominal ultrasound, and 45 underwent MRI. Two subjects did not undergo MRI due to claustrophobia. All 45 patients that underwent MRI underwent both diffusion-weighted and conventional MRI. Images were interpreted in three stages. First, the diagnosis was made based on diffusion-weighted MR images only. Second, the diagnosis was made based on conventional MR images only. And third, the diagnosis was made by reviewing both simultaneously. Sensitivity and specificity were determined for each of the three diagnostic approaches, and the McNemar test was used to determine any significant differences between the three. Results were considered significant with a two-tailed $p<0.05$. A total of 36 out of 45 patients were found to have acute appendicitis. The diagnostic strategy in which both diffusion-weighted and conventional MR images were utilized simultaneously correctly identified 33 of these (Sensitivity=0.92; 95% CI: 0.78–0.98) as well as all 9 of the patients that did not have appendicitis (Specificity=1.00; 95% CI: 0.66–1.00). Using the McNemar test, the combined strategy of using both diffusion-weighted and conventional MRI simultaneously was found to have statistically higher sensitivity and accuracy than either diffusion-weighted or conventional MRI alone ($p<0.05$). No significant difference was found between sensitivity and accuracy of the diffusion-weighted MRI alone and conventional MRI alone strategies.[30]

Koning, Naheedy, and Kruk[31] conducted a retrospective review of 364 consecutive pediatric patients undergoing gadolinium-enhanced MRI for suspected MRI. Images were interpreted by any of the nine pediatric radiologists, who were not blinded to previous imaging and clinical findings. Pathologic findings served as the reference standard in patients who underwent surgery, while documentation of the alternate diagnosis was used in those that did not. Several patients that did not undergo surgery were imaged using CT in addition to MRI. For these patients, CT was used as the reference standard. To assess diagnostic performance of MRI,

sensitivity and specificity values were calculated. MRI correctly identified 127/132 subjects with confirmed appendicitis (Sensitivity=0.962; 95% CI: 0.914–0.984) and 222/232 subjects without appendicitis (Specificity= 0.957; 95% CI: 0.923–0.976).[31]

Comparison of MRI Following Indeterminate Ultrasound Versus MRI as the Primary Imaging Modality

A subgroup analysis of results from subjects that underwent MRI after indeterminate ultrasound versus MRI those that underwent MRI as the primary modality showed that MRI following indeterminate ultrasound correctly identified 100/102 subjects with confirmed appendicitis and 203/217 subjects without appendicitis. MRI alone correctly identified 350/365 subjects with confirmed appendicitis and 817/843 subjects without appendicitis. An analysis using Fisher's exact test revealed no significant difference between sensitivity (p=0.39) and specificity (p=0.10) of MRI following indeterminate ultrasound versus as the primary imaging modality.

Pooled Data and Comparison to CT

Among the 1,524 subjects from the nine studies included in this review, 467 were found to have acute appendicitis by the reference standard used in each respective study.[24–32] MRI correctly identified 450 of these patients as positive for appendicitis (Sensitivity= 0.96; 95% CI: 0.94–0.98). Of the remaining 1,057 patients that did not have appendicitis, MRI correctly identified 1,024 as negative for appendicitis (Specificity=0.97; 95% CI: 0.96–0.98). The largest meta-analysis conducted to date on the accuracy of CT in the diagnosis of children with suspected appendicitis found that CT has sensitivity of 0.94 (95% CI: 0.92–0.97) and specificity of 0.95 (0.94–0.97).[9] Using Fisher's exact test, it was found that there is no significant difference between sensitivity (p=0.11) and specificity (p=0.06) of MRI versus CT for diagnosing acute appendicitis in pediatric patients. A summary of the sensitivity and specificity of MRI in the included studies can be seen in Fig. (1) and Table 1.

The nine studies included in this review are not without their limitations. Four studies were limited by small sample size and by being single institution studies. In two studies, the reference standard was not independent of imaging results, as the expert panel had access to previous imaging and/or clinical findings. The study by Orth et al suffered from nonresponse bias, as 170 of 453 potential subjects refused consent. Two studies used MRI with gadolinium-based contrast, while the others used only noncontrast MRI. In three studies, MR images were read by any of the multiple radiologists. This would introduce more bias into the studies than in those in which multiple readers come to a consensus on each image.

DISCUSSION

At the conclusion of this review, it was found that the sensitivity and specificity of MRI for the diagnosis of acute appendicitis in pediatric patients are comparable to the sensitivity and specificity of CT. This is true both if MRI is used as a standalone modality, as well as if it is used only after an indeterminate ultrasound examination. This confirms the hypothesis set at the beginning of this review. Given the amount of radiation exposure associated with CT, discussions should be had about whether CT might be overutilized in the evaluation of suspected appendicitis, especially in pediatric patients who are more susceptible to the effects of radiation. While there are many factors to consider when choosing an imaging modality, it is clear that MRI is a valid choice in the evaluation of suspected appendicitis, and deserves serious consideration.

There are, however, many questions still to be answered about the use of MRI in the evaluation of suspected acute appendicitis in children. For example, although MRI may have comparable sensitivity and specificity to CT, MRI is still associated with higher costs. On the contrary, two recent studies in the Netherlands on utilization of MRI in the evaluation of adults with suspected appendicitis have found a protocol utilizing MRI rather than CT actually resulted in a net savings for their respective institutions.[32,33] Further study is needed to determine the cost-effectiveness of MRI for diagnosis of appendicitis on a broader scale. Some other disadvantages to MRI are the general lack of availability in the emergency setting, slower speed of imaging than CT, and that claustrophobic patients and young children may not be able to tolerate remaining perfectly still for imaging. Hopefully as knowledge about the utility of MRI in emergency situations grows, its availability will increase as well, making its utilization more feasible on a larger scale. As the development of ultra-fast MRI sequences progresses, it is also our hope that it will become easier for claustrophobic and very young patients to tolerate MRI without need for sedation.

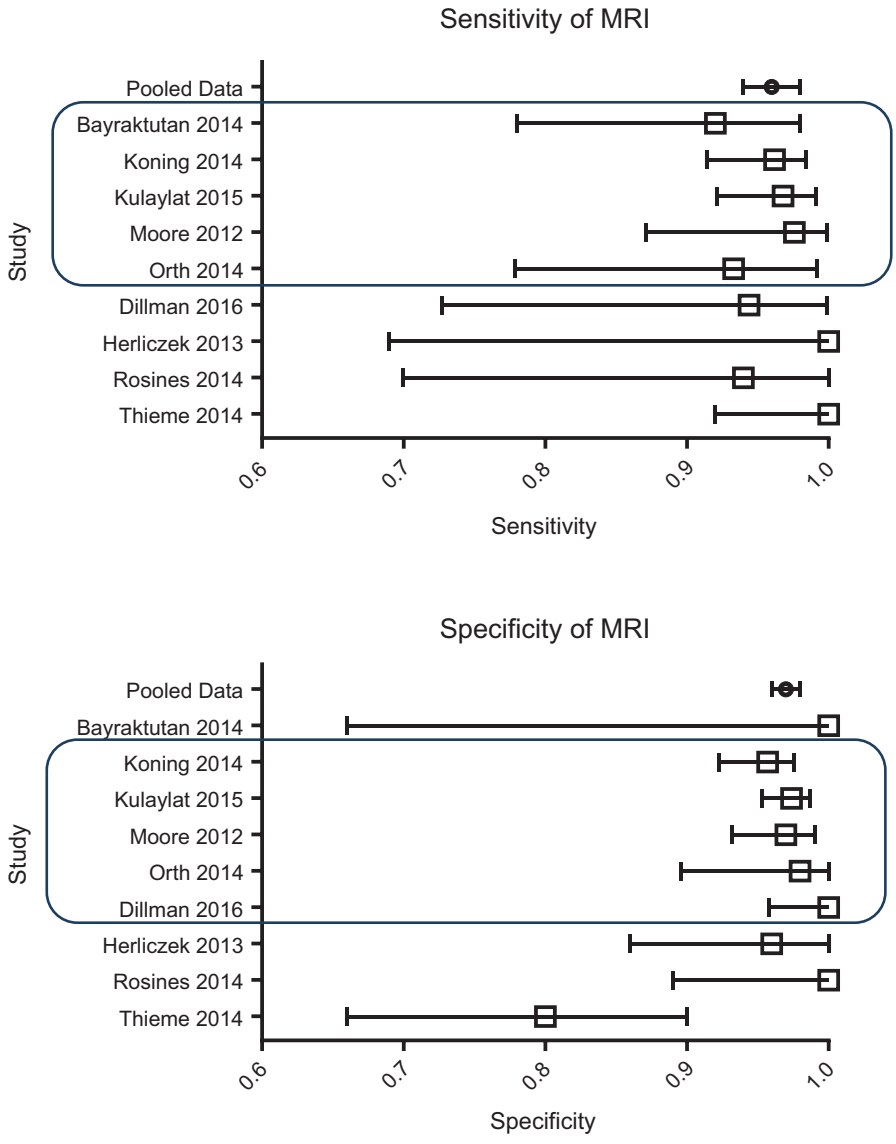

Figure 1. Forest plots summarizing sensitivity and specificity of MRI in the included studies. Studies contained within the boxes studied the use of MRI alone, while those outside the boxes studied the use of MRI after indeterminate ultrasound.

Another concern that remains with regard to the feasibility of using MRI in the evaluation of suspected appendicitis is the relative lack of research on inter-reviewer reliability and the effect of reader experience or inexperience on accuracy. A 2014 study in the Netherlands assessed inter-reviewer reliability between MR experts and nonexperts in 223 cases of suspected appendicitis in adults that were evaluated using MRI. The study found that although experts showed higher accuracy in reading MR images in patients with suspected appendicitis, experts and nonexperts agreed 89% of the time, indicating a good inter-reviewer reliability (kappa=0.78).[34] These results are promising, but more research is still needed to confirm these results as well as to establish inter-reviewer reliability in diagnosing suspected appendicitis in the pediatric population.

It is important to recognize that this review does have some general limitations. First, the reference standard used to determine final diagnoses was not independent of the result of the MRI evaluations. Patients with positive findings for appendicitis underwent surgery, and surgical pathologic findings served as the reference

Table 1. Summary of sensitivity and specificity in the included studies

First Author	TP	FN	FP	TN	Sensitivity (95% CI)	Specificity (95% CI)
Bayraktutan et al. (2014)	33	0	3	9	0.92 (0.78, 0.98)	1.00 (0.66, 1.00)
Koning et al. (2014)	127	10	5	222	0.96 (0.91, 0.99)	0.96 (0.92, 0.98)
Kulaylat et al. (2015)	122	10	4	374	0.97 (0.92, 0.99)	0.97 (0.95, 0.99)
Moore et al. (2012)	40	5	1	162	0.98 (0.87, 1.00)	0.97 (0.93, 0.99)
Orth et al. (2014)	28	1	2	50	0.93 (0.78, 0.99)	0.98 (0.90, 1.00)
Dillman et al. (2016)	17	0	1	85	0.94 (0.73, 1.00)	1.00 (0.96, 1.00)
Herliczek et al. (2013)	10	2	0	48	1.00 (0.69, 1.00)	0.96 (0.86, 1.00)
Rosines et al. (2014)	15	3	1	33	0.94 (0.70, 1.00)	0.92 (0.78, 0.98)
Thieme et al. (2014)	58	9	0	37	1.00 (0.94, 1.00)	0.80 (0.66, 0.91)
Pooled Data	**450**	**40**	**17**	**1,020**	**0.96 (0.94, 0.98)**	**0.96 (0.95, 0.97)**

standard, while the reference standard for patients with negative findings for appendicitis was clinical follow-up. Another limitation is the variation of inclusion and exclusion criteria among the studies included in this review. Some authors chose to use MRI to image only those patients with an inconclusive ultrasound, while others imaged all patients that were to undergo imaging for suspected acute appendicitis. A third limitation is that these studies used differing MRI protocols. Different sequences were used in each study, and two of the nine studies used contrast-enhanced MRI while the others did not. The MRI sequences used in each study are summarized in Table 2. A last potential limitation is publication bias. Results that show high sensitivity and specificity for MRI in the diagnosis of acute appendicitis are more likely to be submitted for publishing. This could have significantly inflated the results for accuracy of MRI.

Despite these limitations, the conclusions of this review remain valid. Although MRI protocol differed between the studies included in this review, this is likely to be the case in different clinical centers that may choose to implement MRI in the evaluation of suspected appendicitis in children. The inclusion of studies that used MRI only after indeterminate ultrasound and as the primary modality is a potential concern, but an analysis of the sensitivity and specificity in these two scenarios revealed no statistically significant difference. The difference in the reference standard used depending on imaging results is also certainly more similar to actual clinical scenarios, as unnecessary surgical interventions should always be avoided. Although a publication bias cannot be completely ruled out, a search of the ClinicalTrials.gov database returned only one result for the search terms 'MRI' and 'appendicitis'.

Table 2. Summary of MRI protocols used in the included studies

First author	Field strength	T1 GRE	T1 TSE	T2 TSE	T2 SSFSE	DWI	STIR	bSSFP	T1 w/ contrast	bSSFP contrast
Bayraktutan	1.5 T		✓	✓*		✓				
Dillman	1.5& 3T				✓*					
Herliczek	1.5& 3T			✓	✓		✓	✓		
Koning	1.5 T				✓	✓		✓	✓	
Kulaylat	1.5& 3T			✓						
Moore	1.5 T				✓*					
Orth	1.5 T	✓		✓*		✓				
Rosines	1.5 T	✓			✓					✓*
Thieme	1.5 T				✓	✓		✓*		

*indicates that fat suppression was used in this sequence.
GRE, gradient-recalled echo; TSE, turbo-spin echo; SSFSE, single shot fast-spin echo; STIR, short inversion time inversion recovery; bSSFP, balanced steady-state free precession; DWI, diffusion-weighted imaging; SPAIR, spectral adiabatic inversion recovery.

CONCLUSION

In conclusion, MR imaging has demonstrated sensitivity and specificity equal to that of the current gold standard test (CT) in the evaluation of pediatric patients with suspected acute appendicitis. MRI is an attractive option in this scenario as it does not require exposure to large amounts of ionizing radiation, which children are more susceptible to. Although more research is needed to determine the cost-effectiveness and feasibility of implementing MRI on a large scale, it is clear that clinicians can make the decision to use MRI without sacrificing diagnostic accuracy.

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APPENDIX A – Evidence Table

First author	Date published	Study design	Evidence level	Study population	Exposure	Results
Bayraktutan	June 2014	Prospective study	2	45 consecutive pediatric patients aged 0–14 presenting to the ED over a 4-month period with diagnosed appendicitis or a nonvisualized appendix on ultrasonography	Patients underwent diffusion-weighted and conventional MR imaging. Diagnosis was made using diffusion-weighted and conventional images alone, and then by combining the two images	The combined MRI strategy achieved sensitivity of 0.92 (33/36; 95% CI: 0.78–0.98) and specificity of 1.00 (9/9; 95% CI: 0.66–1.00), and had better sensitivity and accuracy than diffusion-weighted or conventional MRI alone ($p<0.05$)
Dillman	April 2016	Retrospective study	3	161 children that underwent either MRI ($n=103$) or CT ($n=58$) for suspected appendicitis after an equivocal ultrasound at a single institution over two 1-year periods	Patients underwent MRI or CT as part of evaluation of suspected appendicitis	MRI Sensitivity=0.944 (17/18; 95% CI: 0.727–0.999) Specificity=1.00 (85/85; 95% CI: 0.958–1.00) CT Sensitivity=1.00 (11/11; 95% CI: 0.958–1.00) Specificity=0.979 (46/47; 95% CI: 0.887–1.00) No significant difference between the sensitivities ($p=1.00$) or specificities ($p=0.36$) of MRI versus CT
Herliczek	May 2013	Retrospective study	3	60 children aged 7–17 that underwent MRI after an indeterminate ultrasound for suspected appendicitis between December 2009 and April 2012	Patients underwent MRI as part of evaluation for suspected appendicitis	MRI achieved sensitivity of 1.00 (10/10; 95% CI: 0.69–1.00) and specificity of 0.96 (48/50; 95% CI: 0.86–1.00) in this sample
Koning	August 2014	Retrospective study	3	364 consecutive pediatric patients that underwent contrast-enhanced MRI for suspected appendicitis between November 2012 and September 2013	Patients underwent contrast-enhanced MRI as part of evaluation for suspected appendicitis	Contrast-enhanced MRI achieved sensitivity of 0.962 (127/132; 95% CI: 0.914–0.984) and specificity of 0.957 (222/232; 95% CI: 0.923–0.976)
Kulaylat	August 2015	Retrospective study	3	510 pediatric patients aged 3–17 that underwent imaging for suspected appendicitis at one institution between July 2011 and December 2013	Patients underwent an MRI examination as part of evaluation for suspected appendicitis	MRI achieved sensitivity of 0.968 (122/126; 95% CI: 0.921–0.991) and specificity of 0.974 (374/384; 95% CI: 0.953–0.987) in this sample

APPENDIX A (*Continued*)

First author	Date published	Study design	Evidencelevel	Study population	Exposure	Results
Moore	September 2012	Retrospective study	3	208 pediatric patients aged 5–17 that were evaluated in the emergency room for suspected appendicitis between March 2010 and March 2011	All patients underwent MRI as the primary imaging modality in the evaluation for suspected appendicitis	MRI achieved sensitivity of 0.976 (40/41; 95% CI: 0.871–0.999) and specificity of 0.970 (162/167; 95% CI: 0.932–0.990) in this sample
Orth	July 2014	Prospective study	2	81 consecutive pediatric patients aged 4–17 that were seen in the ER for suspected appendicitis between June 2012 and May 2013	All patients underwent both ultrasound and MRI of the abdomen as part of the evaluation of suspected appendicitis	MRI achieved sensitivity of 0.933 (28/30; 95% CI: 0.779–0.992) and specificity of 0.980 (50/51; 95% CI: 0.896–1.00) in this sample
Rosines	November 2014	Retrospective study	3	49 pediatric patients that underwent MRI for suspected appendicitis after an indeterminate ultrasound at a single institution	All patients underwent both contrast-enhanced and unenhanced MRI as part of evaluation of suspected appendicitis	MRI achieved sensitivity of 0.94 (15/16; 95% CI: 0.70–1.00) and specificity of 1.00 (33/36; 95% CI: 0.89–1.00) in this sample
Thieme	March 2014	Prospective study	2	104 consecutive pediatric patients aged 4–18 that presented to the ER with clinically suspected appendicitis between April and December 2009	All patients underwent both ultrasound and MRI of the abdomen as part of evaluation for suspected appendicitis. Three strategies were compared: ultrasound alone, conditional MRI after indeterminate ultrasound, and MRI alone	Conditional MRI Se=1.00 (58/58; 95% CI: 0.92–1.00) Sp=0.80 (37/46; 95% CI: 0.66–0.90) MRI alone Se=1.00 (58/58; 95% CI: 0.92–1.00) Sp=0.89 (41/46; 95% CI: 0.76–0.96) No significant difference was found in the sensitivities or specificities of the two strategies ($p>0.05$)

Evidence levels were determined as follows:

1. Randomized controlled trials
2. Nonrandomized controlled trials
3. Observational studies with controls
4. Observational studies without controls

Are Medical Students Becoming Less Altruistic and More Money-Oriented? A Three Wishes Survey

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Purpose: *In this study, we assessed the underlying values and goals of current medical students by examining personal wishes. We also aimed to determine the impact of the increased financial burden of medical training on students' motivations by comparing current wishes to those of students from 1999. We also examined the relationships between types of wishes, choice of future medical specialty, and demographic characteristics.*

Method: *An anonymous survey with the question, 'If you had three wishes, what would you wish for?', and items pertaining to specialization choice and demographics was completed by 418 medical students. Wishes were coded into 17 categories. Results were compared with a previous survey conducted in 1999.*

Results: *The largest category of wishes was altruism (40% of students), followed by achievement (36%) and money (34%). Significantly, more medical students in 2015 had altruistic and achievement wishes compared to that of students in 1999. However, there was no significant increase in money-related wishes in the 2015 cohort compared to students from 1999. Final year students were more likely to report power-related wishes and male medical students had significantly more wishes related to power, money, and self-esteem. Students who aspired to be surgeons had more affiliation wishes and fewer knowledge-related aspirations. Conversely, medical students planning to enter internal medicine training were more likely to have wishes related to power and self-esteem. Achievement wishes were more common among individuals wanting to enter family medicine.*

Conclusions: *There was no evidence that medical students are becoming less altruistic and more money-orientated. Further, individuals did not appear to become less altruistic or increasingly financially driven as they progressed through the medical course.*

Keywords: *undergraduate; motivations; altruism; money; specialization*

INTRODUCTION

Medical education plays an important role in defining the values, attitudes, and behavior of the future medical workforce.[1,2] Research suggests that core constructs of patient-centered care such as empathy,[3–5] altruism, and idealism[6,7] wane over the course of medical school. Furthermore, when comparing attitudes at the beginning of study with those at completion, medical students report increased cynicism and decreased concern for 'undeserving' and marginalized patients.[8] The reasons underlying such changes are unclear. Some researchers suggest that the shift in attitudes and values serves as a means to cope with stressful clinical situations.[6] Others implicate professional socialization, disenchantment with the educational process, and the impact of the hidden curriculum.[9]

Similarly, research suggests that medical education is becoming more financially burdensome, which may be modifying the values and attitudes of medical students.[10,11] In New Zealand, annual fees for the medical program have increased from 7,980 New Zealand dollars (NZD or NZ$) in 1999 to NZ$14,788 in 2016, an increase of 170% after adjustment for inflation.[12,13] Additionally, the payment of university fees with student loans is common; currently, 92% of domestic medical students use government loans with an average debt of NZ$76,000 compared to NZ$26,000 in 1999.[14,15] It is estimated that more than 20% of the current graduating class at the University of Auckland will have a student loan more than NZ$100,000. Similar trends are reported in Australia.[16] In other countries, educational debt can be much higher; for example, in the United States, average levels of medical student debt exceed US$150,000, with over a quarter of medical

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students having debt of greater than US$250,000.[17,18] For the majority of students, medical education is a loan-dependent investment which necessitates considerable financial sacrifice. It follows that current medical students may be more financially motivated than their predecessors.

The personal values and attitudes of medical students can also influence future career decisions. Research suggests that students who prize connection with others and lifestyle factors have an increased likelihood of entering primary care.[19] Conversely, individuals who cite prestige and income as important personal values are more likely to foresee themselves applying for surgical training programs. Medical students with an increased focus on achievement-related objectives report greater consideration of internal medicine specialties.[20,21]

Accurate assessment of the values and attitudes of medical students is a difficult task. The validity of directly questioning individuals about their values is disputed as responses may be influenced by expectations and a social desirability bias.[22] An unconventional method that can be employed to somewhat bypass these constraints is the examination of medical students' wish lists. Wishes are defined as goals that are unconstrained by the limitations of the real world. In addition, personal wishes may reveal the values held by individuals and can potentially provide insights into the type of person they aspire to be.[23]

A previous study conducted at the University of Auckland Medical School revealed that the students were likely to have wishes related to happiness (34% of students), money (32%), and altruism (31%), with little variation in the types of wishes over the years of the medical course. Female medical students were more likely than males to make wishes related to happiness, altruism, and intimacy. Conversely, men had a greater rate of sexual wishes.[24]

This study aimed to analyze the wish lists of medical students at the University of Auckland by asking the question 'If you were given three wishes, what would you wish for?'. We sought to explore the following questions:

Given the financial burden of the medical course, are medical students becoming more or less altruistic and money-oriented?

Do students become more money-oriented and less altruistic as they go through the medical program?

Are there any significant relationships between types of wishes, choice of future medical specialty, and demographic characteristics?

METHODS

Study Design

All medical students (1,194 individuals) at the University of Auckland were emailed a link to an anonymous survey which included the question 'If you had three wishes, what would you wish for?' as well as an assessment of demographic variables. The survey administered in this study is comparable to that used by Petrie and colleagues in 1999. However, there were differences with regard to the method of administration. Specifically, students in 1999 completed the survey using pen and paper during a lecture break, whereas medical students in this study completed the questionnaire online and in their own time. In both studies, potential participants were not provided any incentive to participate. We collected data over a period of 2 months from September to November 2015. Wishes were coded by two research assistants into 17 categories using a scheme derived from King and Broyles (see Table 1).[25] This coding scheme was also used in the 1999 study. Inter-rater reliability between the two judges was high (Cohen's $\kappa = 0.93$). In the case of disagreement, a third coder read the statement, and assignment to wish type was resolved by discussion. Wishes could be coded into more than one category; for example, the wish 'to win a Nobel prize for finding the cure to diabetes' was assigned to categories of 'achievement' and 'altruism'. Participants' anticipated specialization choice was indexed by dividing specialty into three broad categories: surgery, internal medicine, and family medicine. This study was approved by the University of Auckland Human Participants Ethics Committee (Protocol No. 015504) and the University of Auckland Medical Programme Directorate.

Data Collection and Analysis

Data were collected and collated using Qualtrics Research Suite survey software. Results were analyzed using the Statistical Package for the Social Sciences (version 23). An alpha level of 0.05 was used to denote significance. Subgroup analyses were conducted using chi-squared tests, and logistic regression was used to determine relationships between types of wish, specialization choice, and demographic variables, and to allow for adjustment of confounding variables. Logistic regression results are presented with odds ratios (ORs) and 95% confidence intervals (CIs).

RESULTS

The study sample comprised 418 medical students from the University of Auckland, representing 35% of individuals in the MBChB program. Demographic

Table 1. Categories of wishes and examples.

Wish	Examples
Altruism	For all humans to have their desired standard of living. For governments to prioritize people's welfare over the creation of capital.
Achievement	To win a Nobel prize. To become a world-renowned expert in the field I decide to specialize in.
Money	To have a whole lotta cash. To be financially secure with no student loan or mortgage.
Happiness	To be happy and content always. To remain happy and have stability in my life.
Health	To be as physically fit as possible for my current age. To be healthy and mobile forever.
Intimacy	To meet my soul mate. To marry a beautiful girl who will support me in all my endeavors.
Time	For better time management skills. That I could freeze and unfreeze time at will.
Power	To have control over time, space, and matter. For the power to read minds, especially of my consultants.
Travel	To see Europe and Asia. To travel to (and return from) Mars.
Self-esteem	To defeat this anxiety and depression. I wish I weren't me.
Affiliation	To continue to have a great bunch of people around me. To maintain a good network of friends and colleagues.
Knowledge	To have all the knowledge of our lecturers. To have wisdom – King Solomon style.
Appearance	A permanent natural tan. A big butt.
Undoing	That my granddad was still alive. That I could go back to when I was a little kid.
Religious	That my religion didn't see same sex relationships as 'wrong'. That everyone would know the love of God.
Food	To always eat Michelin star quality food. To have an endless supply of Burger King Rodeo burgers.
Sexual	To 'get with' whomever I wanted. To be a powerhouse in bed.

characteristics of the sample are presented in Table 2. The sample was predominantly female, New Zealand European, and had not completed a degree prior to the MBChB program. Comparison of those who responded to the survey with non-respondents highlighted an over-representation of female ($p < 0.001$) and New Zealand European individuals in the study sample ($p < 0.001$).

The largest category of wishes was altruism, with 161 students (40%) having at least one altruistic wish. Achievement wishes (36%, 151) formed the next largest category, followed by money (34%, 142) and happiness wishes (28%, 118). Twenty-one percent of wishes were coded into more than one category.

We examined differences in rates of wishes across different years of the medical school program. We found no reduction in the proportion of altruistic wishes and no increase in money-related wishes in the latter years of the program. However, being in the final year of the medical program was a significant predictor of reporting a power-related wish (OR = 5.01, 95% CI = 1.29–20.0, $p = 0.02$). Significance was maintained after adjusting for gender,

Table 2. Demographic characteristics of the study sample ($n = 418$).

	M (SD)/%
Age	22.7 (3.3)
Gender	
Male	41.2
Female	58.8
Year	
II	24.4
III	26.8
IV	15.3
V	19.1
VI	14.4
Entry	
Undergraduate	70.1
Graduate	29.9
Ethnicity*	
New Zealand European	48.8
Asian	19.4
Maori	10.0
Indian	5.5
Pacific Island	5.0
Other	11.2

*Percentages may not total 100 because of rounding.

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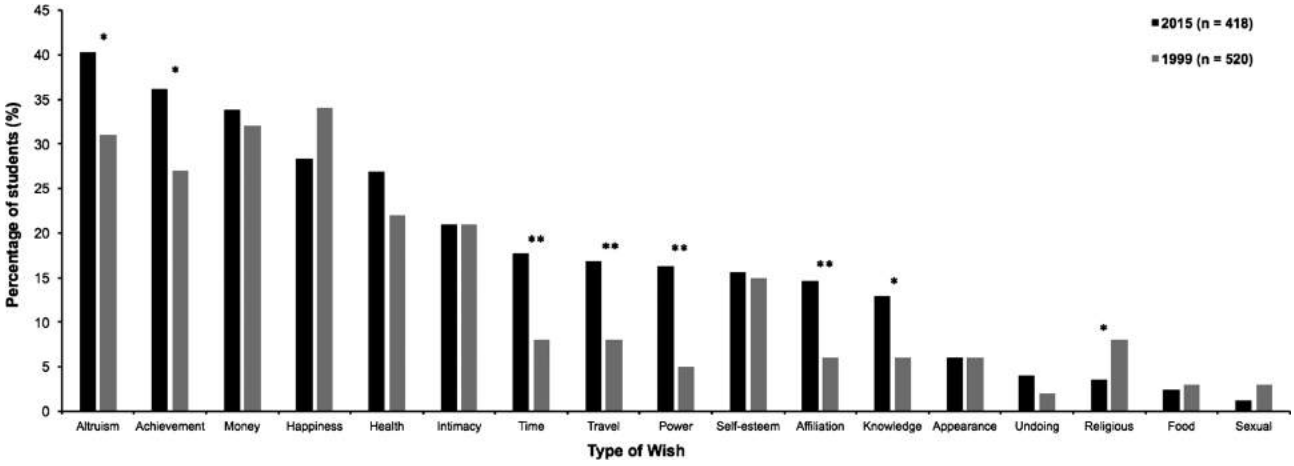

Figure 1. Comparison of medical student wishes in each category (%) collected in 1999 and 2015. *Denotes significant difference at $p < 0.05$. **Denotes significant difference at $p < 0.001$.

demonstrating there was no confounding by sex (OR = 4.78, 95% CI = 1.21–18.89, $p = 0.03$ (see Table S1).

A comparison of the proportion of wishes by category between 2015 and 1999 is presented in Figure 1. Achievement, altruism, happiness, and money-related wishes formed a significant proportion of wishes in both cohorts. However, in contrast to expectations, the most popular category of wish has changed from happiness (1999) to altruism (2015), with significantly more medical students in 2015 having an altruistic wish compared to 1999 (40% vs. 31%, $p < 0.01$). Similarly, there were significant increases in the proportion of students with achievement, time, travel, power, affiliation, and knowledge-related wishes. By contrast, the proportion of students with religious wishes had significantly reduced over time ($p = 0.01$).

With regard to specialization choice, 42% of the sample (95 students) aspired to become internal medicine specialists, compared to students who aspired to be surgeons (30%, 68) and family doctors (28%, 65). Comparisons were made between the three groups (internal medicine specialists, surgeons, and family doctors). Individuals who planned to become surgeons were more likely to have affiliation wishes ($p < 0.01$) and less likely to have knowledge wishes than the other two groups ($p = 0.01$). Those who foresaw themselves practicing in internal medicine were more likely to have wishes related to power ($p = 0.01$) and self-esteem compared to those not interested in internal medicine training ($p = 0.01$). Wishes pertaining to achievement were more common among individuals who wanted to enter family medicine relative to those who desired to enter surgical or internal medicine training ($p = 0.02$).

Power ($p < 0.01$), money ($p = 0.03$), and self-esteem wishes ($p = 0.05$) were more common among male medical students. Interestingly, being male was also found to be a significant predictor of anticipated engagement in a surgical specialty (OR = 3.70, 95% CI = 2.13–6.43, $p < 0.01$).

DISCUSSION

Contrary to expectations, comparison with medical school cohort data from 1999 highlights no increase in money-related wishes. However, a significant increase in altruistic and achievement-related wishes was observed. Altruistic wishes were the most popular category of wish among current medical students, and a high rate of altruistic wishes was demonstrated in all stages of the medical program. Medical students in the final year of study were significantly more likely to have power-related wishes in comparison with their junior colleagues. With regard to specialization preference, individuals who wanted to be surgeons were more likely to have affiliation wishes and less likely to have knowledge wishes. Conversely, students who wanted to enter internal medicine training were more likely to have wishes pertaining to power and self-esteem. Achievement-related wishes were more common among medical students who saw themselves as future family doctors.

There was a high rate of altruistic wishes among students and no evidence of a decline in altruism with progression through the medical program. Furthermore, it

appears that a significantly greater proportion of medical students in 2015 had altruistic aspirations compared to the medical school cohort of 1999. The widespread reporting of altruistic wishes among the students surveyed in this study may be attributed to the current medical school selection process. Currently, there is an increased focus on humanistic characteristics of medical school applicants; a student's academic prowess alone is inadequate to guarantee entry into medical school; academic grades must be supported by engagement in activities that demonstrate social responsibility and concern for the welfare of others.[26,27]

Findings of this study also suggest that achievement-related aspirations are now more pervasive among medical students compared to previous years. It is widely acknowledged that the academic standard of entry for medical school has risen in comparison with previous decades. Higher scores with regard to standard high school examinations, university grade point averages, and aptitude tests are now necessary to meet the standards required for an interview.[13] Consequently, the current cohort of medical students are likely to be more achievement-oriented than their past colleagues.[27,28] This may impact the specialty aspirations of medical students, with fewer individuals wanting to enter training programs for family medicine. Such a trend is evident in the literature with recent studies of medical graduates highlighting greater interest and engagement in internal medicine and surgical subspecialties relative to family medicine and public health.[29]

An unexpected finding was the relative stability of money-related wishes when comparing current students to the 1999 cohort. Over the past 16 years, the financial burden of studying medicine has increased dramatically; fees for the medical course have risen exponentially in New Zealand, and the use of student loans to fund study is now common. The lack of an increase in financial wishes in spite of increased monetary pressures supports research, highlighting altruism and happiness as the main drivers of medical students' values.[24,26]

The results of this study also reveal an increased incidence of power-related wishes among students in the final year of the medical program. The final year is unique in that it aims to immerse the student in the clinical context as a functional but subordinate member of a hierarchical medical team.[30] Exposure to such situations may influence students to wish for situations or outcomes where they are able to exert a stronger personal influence over their environment.

We found that male medical students made a greater number of power, money, and self-esteem wishes than their female counterparts. Males were also more likely to anticipate entering surgical training, a career which is likely to provide means by which such wishes can be fulfilled. These findings are consistent with other studies of medical students' wishes, as well as the broader scientific literature concerning gender roles.[7,31] It is widely accepted in the field of evolutionary psychology that men are more likely to engage in pursuits that allow them to establish dominance in a group compared to women. Thus, greater power, money, and self-esteem wishes may reflect this aspiration.[32,33]

Students' wishes were associated with preferred specialization choice, which suggests that certain specialties attract individuals with particular goals and values. However, the findings of this study with regard to specialization choice are somewhat counterintuitive as they do not directly reflect the above concept. One would expect a surgical preference to be associated with greater power and money wishes, and conversely, a preference for family medicine to be related to affiliation and lifestyle aspirations.[19–21] Thus, it may be that individuals' wishes also reveal means by which they hope to overcome perceived personal weaknesses or shortcomings, rather than reflecting realistic aspirations of a particular specialty.

The strengths of the study are the use of a novel method for assessing student motivation that is likely to be less affected by social desirability bias. A large sample of students across all 5 years of the medical school course was also obtained. The collection of data from the same medical school program 17 years prior allowed a valid comparison of how medical students' wishes have changed over time. Some limitations of the study should be highlighted. It should be noted that response rate differs between the 1999 and 2015 cohorts, with a lower response rate recorded in the latter group. Students in 1999 completed the survey using pen and paper in a lecture break, whereas students in 2015 completed the survey online and in their own time. Thus, the differences in response rate between the 1999 and 2015 cohorts are likely attributable to the differing methodologies of the two studies. It is also important to acknowledge that participants were not provided any incentive to participate in this research; thus, responding may be biased toward medical students who were more altruistically motivated. Finally, the data collected are cross-sectional in nature, which restricts the drawing

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of causal relationships. Longitudinal research is also necessary to determine how financial, altruistic, and other motivations of medical students change once they enter the clinical workforce.[34]

CONCLUSIONS

Asking about personal wishes can provide insights into the values and aspirations of medical students, while minimizing compromise due to social desirability bias. Despite increased financial burden, it appears that medical students at the University of Auckland are becoming more altruistic and achievement-oriented with no associated increase in financial motivations; however, this requires further research. There is stability of altruistic wishes as students progress through the medical program.

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