EMA Emergency Medicine Australasia

Emergency Medicine Australasia (2022) **34**, 769–778 doi: 10.1111/1742-6723.13974

ORIGINAL RESEARCH

Trends in computed tomography aortography and acute aortic syndrome in an emergency department within Aotearoa New Zealand

Steve WFR WAQANIVAVALAGI [1,2,3] Sameer BHAT [4] Franco SCHREVE,[1] Paget MILSOM,[3] Colleen J BERGIN[5] and Peter G JONES [1,4]

[1]Adult Emergency Department, Auckland City Hospital, Auckland District Health Board, Auckland, New Zealand, [2]Department of Medicine, The University of Auckland, Auckland, New Zealand, [3]Green Lane Cardiothoracic Surgical Unit, Auckland City Hospital, Auckland District Health Board, Auckland, New Zealand, [4]Department of Surgery, The University of Auckland, Auckland, New Zealand, and [5]Department of Radiology, Auckland City Hospital, Auckland District Health Board, Auckland, New Zealand

Abstract

Objective: Acute aortic syndrome (AAS) comprises a triad of life-threatening aortic conditions that are difficult to diagnose because of their non-specific clinical presentations. Contrast-enhanced computed tomography aortography (CTA) has a high sensitivity and specificity for these conditions. However, under- and over-investigation of patients with suspected AAS using CTA carries significant risk. The aim of the present study was to evaluate the diagnostic imaging practices of CTA use for patients presenting to an ED with suspected AAS.

Methods: All atraumatic thoracic CTAs performed on patients aged ≥15 years old with suspected AAS who presented to Auckland City Hospital between 2009 and 2019 were included. Outcomes of interest were the annual ED and population incidences of AAS, and the rate of CTAs performed.

Results: A total of 1646 CTAs were included. There were 135 (8.2%) cases of at least one AAS diagnosis and 220 (13.4%) cases where an alternative diagnosis was made. The population-adjusted number of AAS diagnoses remained relatively stable over the study period, with a mean annual AAS incidence of 19.6 (95% confidence interval 9.9–33.7) per 100 000 patients, and 3.2 (95% confidence interval 1.6–5.4) per 100 000 population. The number of ED presentations increased during the study period, along with the population-adjusted rate of CTAs performed, from approximately 150 per 100 000 patients (2009) to 350 per 100 000 patients (2019).

Conclusions: Thoracic CTA use for investigating suspected AAS in our ED has recently increased. However, the annual incidence of AAS did not increase over the same period, but was higher than reported in overseas institutions.

Key findings

- Between 2009 and 2019, there were 135 (8.2%) cases of at least one acute aortic syndrome diagnosis and 220 (13.4%) cases where an alternative diagnosis was made.
- During the study period, thoracic CTA use for investigating suspected acute aortic syndrome in Auckland City Hospital ED increased.
- The annual incidence of acute aortic syndrome did not increase during the study period, but was higher than reported in overseas institutions.

Key words: *acute aortic syndrome, aortic dissection, aortography, computer-assisted tomography, emergency.*

Introduction

Acute aortic syndrome (AAS) comprises the triad of acute aortic dissection, acute intramural haematoma and penetrating aortic ulcer.[1] These life-threatening aortic conditions are difficult to diagnose in the ED because of their non-specific clinical presentations.[2,3] Although there is increasing promise in utilising risk stratification tools such as the aortic dissection detection risk score, a validated rule-out test remains to be developed.[4]

Correspondence: Dr Steve WFR Waqanivavalagi, Department of Medicine, The University of Auckland, Auckland 1142, New Zealand. Email: s.waqanivavalagi@auckland.ac.nz

Steve WFR Waqanivavalagi, MBChB, BMedSc (Hons), Cardiothoracic Registrar; Sameer Bhat, MBChB, BMedSc (Hons), House Officer; Franco Schreve, FACEM, Emergency Medicine Specialist; Paget Milsom, FRACS, Cardiothoracic Surgeon; Colleen J Bergin, FRANZCR, Radiologist; Peter G Jones, PhD, FACEM, Emergency Medicine Specialist.

Accepted 17 March 2022

The complexity of diagnosing AAS correlates with the observed high misdiagnosis rates.[5,6] Thus, emergency physicians are less likely to rely on clinical experience and instead investigate patients with advanced imaging which, in most EDs, involves contrast-enhanced computed tomography aortography (CTA).[7,8] Despite the high sensitivity and specificity of CTA for evaluating AAS, resource constraints in some centres have limited its widespread availability and use.[9]

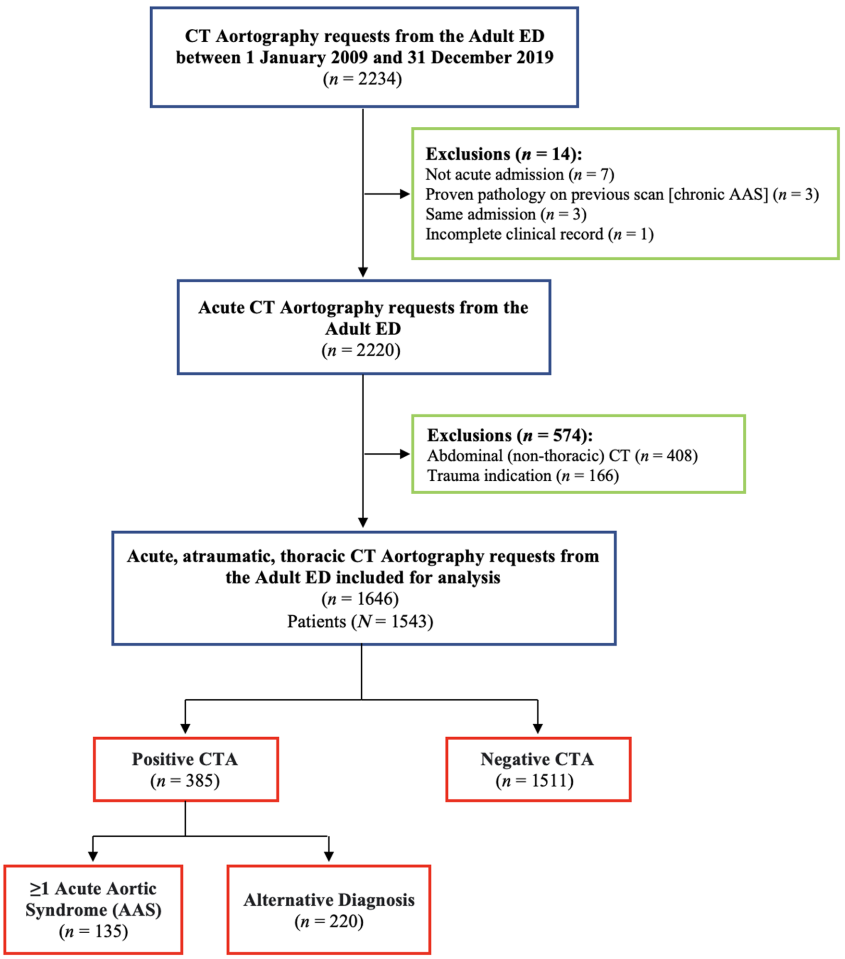

Figure 1. *Flow diagram representing the screening and selection process for relevant acute, atraumatic, thoracic computed tomography aortography cases.*

The non-specific clinical presentation of AAS means that it is often difficult to determine which patients require imaging. Decision-making should ideally be based on whether patients have met the minimum threshold for CTA, which may vary based on their pre-test probability for AAS, as well as individual patient factors. However, there are risks associated with over- and under-investigating patients with suspected AAS using CTA. Hence, emergency physicians must consider two competing interests: to definitively investigate patients with a clinical presentation concerning for AAS, while concurrently avoiding unnecessary imaging in patients with a low pre-test probability for AAS. Appropriate patient selection is therefore key in minimising rates of over-investigation and deciding which patients to prioritise for CTA.[6]

There are now large, international, cohort studies of patients with AAS, including the International Registry of Acute Aortic Dissection.[10] Hence, the paucity of data with respect to the CTA imaging practices of emergency physicians in New Zealand (NZ) is surprising. Therefore, the

TABLE 1. *Acute aortic syndrome diagnoses in selected contrast-enhanced computed tomography aortography cases*

Diagnosis	Total number	Proportion of positive CTAs (%) ($n = 135$)	Proportion of total CTAs (%) ($n = 1646$)
Aortic dissections	104	77.0	6.3
Stanford type A aortic dissection	66	48.9	4.0
Stanford type B aortic dissection	38	28.1	2.3
Acute intramural haematoma	47	34.8	2.9
Penetrating aortic ulcer	8	5.9	0.5
Aortic rupture	25	18.5	1.5

CTA, computed tomography aortography; *n*, number of CTA scans.

TABLE 2. *Alternative (non-acute aortic syndrome) diagnoses in selected contrast-enhanced computed tomography aortography cases*

Cause	Total number	Proportion of positive CTAs (%) ($n = 220$)	Proportion of total CTAs (%) ($n = 1646$)
Vascular	27	12.3	1.6
Non-aortic vascular injury	10	4.5	0.6
Graft abscess/infection	3	1.4	0.2
Endoleak	2	0.9	0.1
Occluded non-aortic vascular grafts	2	0.9	0.1
Aortic embolus	3	1.4	0.2
Worsening compression of true lumen	1	0.5	0.1
Impending rupture of aortic aneurysm	2	0.9	0.1
Splenic infarct	2	0.9	0.1
Renal infarct	2	0.9	0.1
Thoracic/cardiorespiratory	74	33.6	4.5
Acute coronary syndrome	7	3.2	0.4
Pulmonary oedema	3	1.4	0.2
Pericardial effusion	9	4.1	0.6
Pneumomediastinum	1	0.5	0.1
Pulmonary embolism	13	5.9	0.8
Pleural effusion/haemothorax	7	3.2	0.4
Pneumothorax	1	0.5	0.1
Lower respiratory tract infection	23	10.5	1.4
Lung/pleural mass/malignancy	4	1.8	0.2
Cardiac mass/malignancy	1	0.5	0.1
Other intrathoracic mass/ malignancy	4	1.8	0.2
Intra-thoracic haemorrhage NOS	1	0.5	0.1
Gastrointestinal	88	40.0	5.3
Complication of cholecystectomy	1	0.5	0.1
Cholelithiasis	9	4.1	0.6
Choledocholithiasis	7	3.2	0.4
Cholecystitis	15	6.8	0.9
Cholangitis	1	0.5	0.1
Hernia	7	3.2	0.4
Gastroduodenal perforation	3	1.4	0.2
Gastroduodenal ulcer	1	0.5	0.1
Gastritis	2	0.9	0.1
Duodenitis	1	0.5	0.1
Pancreatitis	15	6.8	0.9
Infective or inflammatory colitis	2	0.9	0.1
Infective or inflammatory enteritis	2	0.9	0.1

(*Continues*)

TABLE 2. *Continued*

Cause	Total number	Proportion of positive CTAs (%) ($n = 220$)	Proportion of total CTAs (%) ($n = 1646$)
Appendicitis	2	0.9	0.1
Epiploic appendagitis	1	0.5	0.1
Diverticulitis	1	0.5	0.1
Small bowel obstruction	2	0.9	0.1
Volvulus	1	0.5	0.1
Intussusception	1	0.5	0.1
Ischaemic bowel	2	0.9	0.1
Constipation	2	0.9	0.1
Oesophagitis/cancer	3	1.4	0.2
Oesophageal tear/rupture	3	1.4	0.2
Intra-abdominal mass/malignancy	2	0.9	0.1
Intra-abdominal haemorrhage NOS	2	0.9	0.1
Genito-urinary	9	4.1	0.6
Renal mass/malignancy	1	0.5	0.1
Retroperitoneal haemorrhage NOS	1	0.5	0.1
Ureteric calculus	6	2.7	0.4
Adnexal mass/malignancy	1	0.5	0.1
Musculoskeletal	22	10.0	1.3
Uncomplicated aortic aneurysm or stable aortic disease	155		9.4

CTA, computed tomography aortography; *n*, number of CTA scans; NOS, not otherwise specified.

objectives of the present study were to evaluate the diagnostic imaging practices for evaluating patients with suspected AAS using CTA in a NZ tertiary referral ED, and then to compare them with those of similar institutions and healthcare settings globally.

Methods

Ethics and governance

The present study was reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology guidelines (Appendix S1).[11] Ethics approval was obtained from the Auckland Health Regional Ethics Committee (AH1260) (Auckland, NZ) and Institutional Review Board approval was obtained from the Auckland District Health Board (ADHB) Research Review Committee (A+ 8879).

Study design and setting

This retrospective, observational, cohort study was conducted at Auckland City Hospital (ADHB, Auckland, NZ), which is both a tertiary referral centre and an academic teaching hospital. Auckland City Hospital serves a mostly urban patient population, with a dedicated adult ED that currently manages approximately 76 000 patients, aged ≥15 years, per annum.

Case selection

The electronic patient database at Auckland City Hospital was queried for all presentations to the adult ED of patients >15 years of age who were investigated with CTA for a diagnosis of suspected AAS by an emergency physician between 1 January 2009 and 31 December 2019. For patients who were investigated with more than one CTA during the specified study period, each CTA request was included, provided it was performed on an independent and unrelated presentation to the ED. Only the index scan in each separate ED presentation was analysed. Patients were excluded if they presented to the ED on an elective or semi-elective basis, or if they were diagnosed with AAS based on a previous CTA that did not meet the above specified criteria (i.e. chronic AAS), or was performed outside of the study period. Patients were also excluded if their CTA did not evaluate the thoracic aorta (e.g. abdominal CTA), or if their CTA was performed for reasons other than suspected AAS (i.e. trauma). Cases with an incomplete clinical record (e.g. incomplete

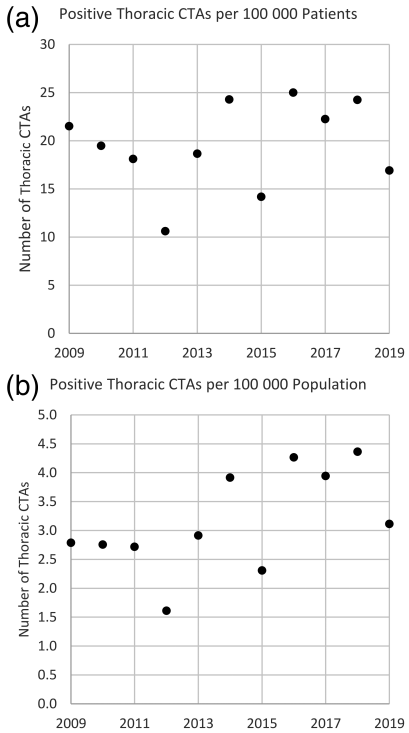

Figure 2. *Population-adjusted annual incidence of acute aortic syndrome diagnoses per (a) 100 000 patients presenting to the adult ED and (b) 100 000 Auckland City Hospital catchment population.*

ED admission note) were also excluded.

Data retrieval and extraction

Data were obtained from the clinical records of each included case using Concerto (Orion Health, Auckland, NZ) and 3M ChartView (3M Company, Salt Lake City, UT, USA) electronic systems. These clinical record systems rely on data entry by clinicians when patients engage with the healthcare system, with regular auditing of these data for their accuracy and validity by specialist clinical records staff employed by the ADHB. The date of CTA and scan report findings, which are based on documentation by a consultant or attending radiologist, were extracted into a pro forma Microsoft Excel 2016 (Microsoft Corporation, Redmond, WA, USA) spreadsheet. Each CTA report was reviewed independently by two authors to ensure concordance between the extracted data, and any ambiguity was resolved with thorough discussion among the two assessing authors (SWFRW and SB). Population data were sourced electronically using census data collected by Statistics New Zealand.

Outcome measures

The primary outcome was the annual incidence of AAS per ED patient presentation and within the Auckland City Hospital catchment population. Secondary outcomes included the annual number of thoracic CTAs performed, in terms of the total number of scans, the number of scans that were positive for one or more AAS and the number of scans that were negative for an AAS, as well as the annual number of presentations to the adult ED with suspected AAS, and the population serviced by the adult ED. CTAs were considered positive for an AAS if reference were made to any one of: acute aortic dissection, acute intramural haematoma or penetrating aortic ulcer, based on findings documented by a consultant or attending radiologist. Although not strictly included within the AAS definition,[1] aortic rupture was also included within the scope of our AAS

TABLE 3. *Annual trends in contrast-enhanced computed tomography aortography (CTA), presentations and population serviced by the adult ED*

Year	AAS diagnoses (N)	ED patients (n_1)	Population (n_2)	ED incidence (n_1/100 000/year)	Population incidence (n_2/100 000/year)
2009	10	46 488	358 500	21.5	2.8
2010	10	51 350	362 700	19.5	2.8
2011	10	55 236	367 600	18.1	2.7
2012	6	56 604	372 000	10.6	1.6
2013	11	58 979	377 400	18.7	2.9
2014	15	61 768	382 800	24.3	3.9
2015	9	63 450	389 600	14.2	2.3
2016	17	67 993	398 300	25.0	4.3
2017	16	71 913	405 500	22.2	3.9
2018	18	74 219	412 400	24.3	4.4
2019	13	76 924	417 200	16.9	3.1
Mean	12	62 266	385 818	19.6	3.2

AAS, acute aortic syndrome; N, number of AAS diagnoses based on CTA; n, number of patients.

definition because of its similarity in clinical presentation and severity to other causes of AAS.[12] CTAs considered negative for one of the causes of AAS were those that were either positive for an alternative (i.e. non-AAS) diagnosis, or negative scans. Alternative diagnoses were all non-AAS causes of acute presentations to the ED that were identified on CTA.

Statistical analysis

Data were reported as the frequency (*n*) and proportion (%). Continuous data (i.e. annual incidence of AAS per ED patient presentation or population) were reported as the mean with its 95% confidence interval (CI). Trends in the primary and secondary outcomes over time were represented graphically using Microsoft Excel 2016 (Microsoft Corporation). All statistical analyses and calculations were performed using R (version 4.0.5; R Foundation for Statistical Computing, Vienna, Austria).

Results

CTA case selection

A total of 2234 potentially eligible CTA cases were identified over the 11-year study period. After application of the case selection criteria, 1646 acute, atraumatic, CTA scans of the thoracic aorta were performed on 1543 patients. The flow diagram representing the screening and selection process for relevant CTA cases is outlined in Figure 1. Of the 1646 included CTAs, 135 (8.2%) were positive for one or more AAS, 220 (13.4%) were positive for an alternative (non-AAS) diagnosis and 1291 (78.4%) were negative scans. Three patients had AAS proven on a previous CTA (chronic AAS) and were hence excluded from our study.

Diagnoses on CTA

The cause for a patient's acute presentation to the ED was identified in 21.6% (355/1646) of CTAs, of which 38.0% (135/355) diagnosed one or more AAS and 62.0% (220/355) diagnosed an alternative cause.

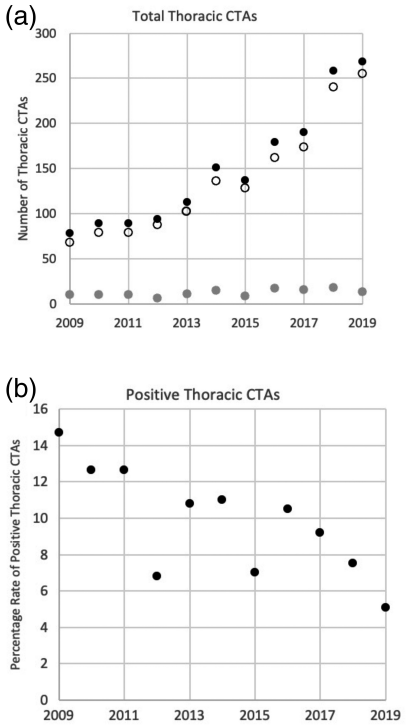

Figure 3. *Acute, atraumatic, thoracic contrast-enhanced computed tomography aortography (CTA) scans performed between 1 January 2009 and 31 December 2019 that were either (a) positive or negative (CTAs considered negative for an acute aortic syndrome [AAS] were either positive for an alternative diagnosis, or negative scans) for an AAS (total number) or (b) positive for one or more AAS (as a proportion). (●), Number of scans; (○), negative scans; (◉), positive scans.*

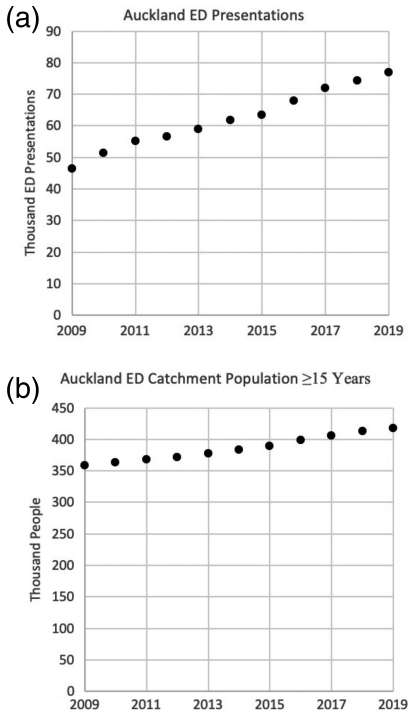

Figure 4. *Presentations to the adult ED at Auckland City Hospital (between 1 January 2009 and 31 December 2019) in terms of the (a) total number of patients and (b) total population serviced.*

Acute aortic syndrome

There were a total of 184 AAS diagnoses from 135 positive CTAs (Table 1). Three distinct/unique AAS were identified on five CTAs, and two distinct/unique AAS were identified on 39 CTAs; although there was no association between the nature of these additional AAS diagnoses. The most frequent diagnosis was acute aortic dissection (77.0% of positive CTAs), of which most constituted Stanford type A aortic dissections (63.5%, 66/104). The remaining diagnoses included 47 acute intramural haematomas (34.8% of positive CTAs), eight penetrating aortic ulcers (5.9% of positive CTAs) and 25 aortic ruptures (18.5% of positive CTAs).

Alternative (non-AAS)

There were 220 alternative diagnoses identified from 220 CTAs (Table 2). According to body system, and in descending order of frequency, these diagnoses were gastrointestinal (40.0%, 88/220), thoracic/cardiorespiratory (33.6%, 74/220), vascular (excluding AAS) (12.3%, 27/220), musculoskeletal (10.0%, 22/220) and genitourinary (4.1%, 9/220) in origin.

Of the 220 alternative diagnoses, 54 critical or immediately life-threatening diagnoses were observed. In descending order of frequency, these diagnoses consisted of pulmonary embolism (5.9%, 13/220), non-aortic vascular injury (4.5%, 10/220), acute coronary syndrome (3.2%, 7/220), oesophageal tear or rupture (1.4%, 3/220), gastroduodenal

perforation (1.4%, 3/220), aortic emboli (1.4%, 3/220), infection or abscess of an aortic graft (1.4%, 3/220), intra-abdominal haemorrhage (0.9%, 2/220), ischaemic bowel (0.9%, 2/220), impending rupture of an aortic aneurysm (0.9%, 2/220), occlusion of non-aortic vascular grafts (0.9%, 2/220), retroperitoneal haemorrhage (0.5%, 1/220), intra-thoracic haemorrhage (0.5%, 1/220), pericardial tamponade (0.5%, 1/220) and worsening compression of the true lumen by the false lumen in one case of previous AAS without a new injury to the vascular wall (0.5%, 1/220).

Primary outcome (incidence of AAS)

The population-adjusted number of AAS diagnoses remained relatively stable over the study period (Fig. 2a, Table 3), with a mean annual incidence of 19.6 (95% CI 9.9–33.7) AAS diagnoses per 100 000 patients presenting to the ED, or 3.2 (95% CI 1.6–5.4) AAS diagnoses per 100 000 population (Fig. 2b, Table 3). The mean incidence of aortic dissections, which were the most common type of AAS, was 15.0 (95% CI 12.4–18.4) events per 100 000 patients per year, and of these, there were 9.5 (95% CI 7.5–12.3) cases of Stanford type A aortic dissections per 100 000 patients per year, or 1.6 (95% CI 1.2–2.0) per 100 000 population per year.

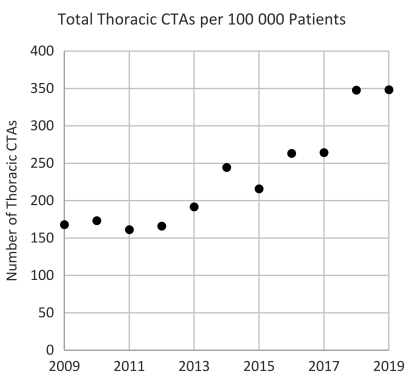

Figure 5. *Population-adjusted total number of computed tomography aortography scans per 100 000 patients presenting to the adult ED at Auckland City Hospital.*

Secondary outcome (trends in CTA and ED presentations)

The annual total number of thoracic CTAs that met the case selection criteria increased over the 11-year study period (Fig. 3a). This increase was mirrored by a rise in both the annual number positive and negative CTAs (i.e. positive for an alternative diagnosis or entirely negative scans) (Fig. 3a). However, relative to the total CTAs performed, the proportion of positive CTAs decreased over this same period (Fig. 3b). There was a rise in the total number of presentations to the adult ED over the 11-year study period (Fig. 4a), which reflects an increase in the Auckland City Hospital catchment population that is serviced by the adult ED (Fig. 4b, Table 3). However, despite adjusting for the increasing number of ED presentations, the total number of CTAs performed consistently increased, from just over 150 per 100 000 patients in 2009 to approximately 350 per 100 000 patients in 2019 (Fig. 5).

Discussion

The present study examined how the use of thoracic CTA for evaluating patients with suspected AAS has changed in a tertiary referral ED. We observed that the mean annual incidence of AAS in our ED, as well as within the Auckland City Hospital catchment population, did not change over the 11-year study period, despite a rise in both the total number of atraumatic, thoracic CTAs performed, as well as the annual number of patients presenting to the adult ED. Stanford type A acute aortic dissection was the most common AAS, and causes that were gastrointestinal in origin were the most common of alternative (non-AAS) presentations to the ED. Of these alternative causes, pulmonary embolism was the most frequently observed critical or immediately life-threatening diagnosis.

Although we identified an overall low incidence of AAS in patients scanned with CTAs, our diagnostic yield of 8.4% was dissimilar to previous studies. In a retrospective study by Lovy *et al.* conducted in New York, only 2.7% (40/1465) of CTAs were positive for an AAS over the 4-year study period.[6] This finding was similar to that of a 2019 study, by Meng *et al.*, who recorded 5.9% (12/205) of their CTAs as positive for AAS at their Canadian institution over a 5-year period.[13] The difference in local NZ incidence of AAS may reflect a higher proportion of Pacific Islander and indigenous Māori patients who experience higher incidences of aortic dissections.[14,15] Wang *et al.* compared the characteristics and outcomes following surgery for type A aortic dissection based on ethnicity; Stanford type A aortic dissections were over-represented in Pacific Islanders, whereas there was no difference for Māori, when compared with patients of other ethnicities.[14] In contrast, Gupta *et al.* demonstrated that Māori were over-represented among patients with Stanford type A aortic dissections at Waikato Hospital (NZ) between 1990 and 2013.[15] These results suggest that ethnicity may be an explanation for the difference in incidence of AAS observed in our study. Further research into risk factors and the incidence of AAS among Pacific Islander and indigenous Māori patients would be of interest, particularly in our present NZ patient cohort.

The annual incidence of acute aortic dissections remained stable in our population over the period of study. Alter *et al.* identified 782 aortic dissections through a retrospective study involving ED visits at 33 suburban and urban New York and New Jersey EDs between 1996 and 2010.[16] They reported an incidence of approximately 8.2 aortic dissection events per 100 000 ED visits, which was similar to Rogers *et al.*, who estimated an annual ED incidence of 10 aortic dissections per 100 000 ED visits.[17] In contrast, the mean annual ED incidence of AAS in our study was 19.6 (95% CI 9.9–33.7) cases per 100 000 patients per year. However, Alter *et al.* and Rogers *et al.* included only acute aortic dissections, whereas our rate

was inclusive of all AAS diagnoses. Nonetheless, even when comparing the mean annual incidence of acute aortic dissections alone, a higher rate of diagnoses was found in our cohort, at 15.0 (95% CI 12.4–18.4) events per 100 000 patients per year. These higher incidences of AAS and aortic dissection identified in our cohort suggest that the use of a risk-stratification tool for ruling out AAS or prioritising patients for CTA, such as the aortic dissection detection risk score combined with a D-dimer cut-off of <500 ng/mL,[4] may be especially helpful in our high-risk patient population.

Stanford type A aortic dissection was the most frequent AAS in our cohort of patients, constituting 63.5% of all acute aortic dissections. This proportion is comparable to those reported elsewhere.[18] Wundram *et al.* recorded 4.93 cases of Stanford type A aortic dissections per 100 000 ED presentations in a retrospective analysis conducted between 2006 and 2016 in Berlin,[19] whereas we reported an incidence of 9.5 (95% CI 7.5–12.3) cases of Stanford type A aortic dissection per 100 000 ED presentations. It remains unclear why the incidences of AAS, aortic dissection and Stanford type A aortic dissection in our ED differ from those reported elsewhere. Variations in ethnic composition of our NZ cohort compared with those seen internationally may be an explanation, particularly given the higher incidences of Stanford type A aortic dissection observed in Māori and Pacific Islander patients.[14,15]

The population-adjusted annual incidence of aortic dissections in the present study was 1.6 (95% CI 1.2–2.0) per 100 000 people per year. In comparison, the mean annual rates of aortic dissections reported elsewhere are as follows: 3.4 per 100 000 per year in New South Wales (Australia);[20] 2.9 per 100 000 per year between 1972 and 1998 in Western Hungary;[21] 2.53 per 100 000 per year between 1992 and 2013 in Iceland;[22] 6.0 aortic dissections per 100 000 people per year between 2002 and 2012 in Oxfordshire (UK);[23] 4.6 per 100 000 people per year between 2002 and 2014 in Ontario (Canada);[24] and 5.6 per 100 000 people per year between 2005 and 2012 in Taiwan.[25] It is noteworthy that the study populations used to calculate the mean annual incidences in these studies were inclusive of all patients (i.e. both adults and children). In addition, the studies conducted in Western Hungary, Iceland and Oxfordshire also included autopsy results, possibly explaining the lower rates observed within our cohort. In addition, the denominator (i.e. all who underwent CTA) in our study was not inclusive of imaging modalities for investigating potential AAS other than CTA, such as transoesophageal echocardiography (TOE) and magnetic resonance angiography (MRA), which may have resulted in an inaccurate estimate of the true incidence of AAS in our population. Future studies should ideally be inclusive of all patients with suspected AAS, using CTA, TOE and MRA, as well as autopsy data, when determining AAS incidence.

Various overseas groups have reported an increasing incidence in AAS.[26,27] In Korea, Lee *et al.* described a significant increase in the incidence of aortic dissection, from 3.76 per 100 000 person-years to 4.82 per 100 000 person-years between 2005 and 2016.[26] Similarly, in Sweden, Olsson *et al.* observed a rise in the incidence of thoracic aortic disease of 52% in men and 28% in women, with a respective incidence of 16.3 and 7.1 per 100 000 per year, from 1987 to 2002.[27] Conversely, our observed annual incidence of both AAS and aortic dissection remained stable over the period of study, despite a population-adjusted rise in both the number of thoracic CTAs performed and annual number of patients presenting to the adult ED. This finding suggests that CTAs are increasingly yielding negative findings in our patient cohort, and a validated risk stratification tool for ruling out AAS may therefore allow better patient selection and prioritisation for CTA, although a tool of this nature remains to be developed.[4]

The present study has some limitations. First, patients who may have been diagnosed with AAS using TOE, MRA or at autopsy, and those who died prior to their imaging or did not undergo any form of investigation were not included. Thus, the true yield of AAS diagnoses may have been underestimated. In addition, patients with AAS diagnosed at an outside institution who were either transferred directly to the operating room or cardiac ICU could not be included because these patients do not proceed through the ED and thus, would not have been captured by our ED coding systems. However, the focus of the present study was on the reliability of thoracic CTA in evaluating suspected AAS in the ED setting, with CTA findings confirmed through documentation on the patient's electronic medical record by a consultant or attending radiologist, increasing the validity and precision of our results. Relatively few autopsies are performed annually in NZ (2000 per year). Thus, the addition of these data would not substantially alter or explain our differing results. Second, the relatively small number of observed AAS events may not provide a sufficiently robust quantity of data through which imaging practices for AAS may be evaluated. Nonetheless, a study period spanning 11 years, coupled with the use of accurate and robust electronic clinical record systems should provide meaningful insight into trends in thoracic CTA imaging and AAS incidences for populations serviced by a large, tertiary referral ED, thereby mitigating the impact of this low prevalence of AAS. However, individual patient-level data, such as age, sex, ethnicity, comorbidities and AAS risk factors, and clinical features on presentation to the ED, could not be extracted or analysed in the present study, which limits the ability to interpret whether the observed increase in CTA requests was appropriate, relative to a patient's risk of AAS. Lastly, the present study evaluated the diagnostic practices of CTA for suspected AAS in a single tertiary referral ED located within NZ, restricting the generalisability of the results. However, a comprehensive comparison with practices of other institutions and patient populations was performed. Several differences in imaging

practices were identified, which collectively, have provided multiple avenues for further research.

Conclusions

The mean annual incidence of AAS within our ED remained stable over the 11-year study period, despite the increasing total number of thoracic CTAs being performed, as well as an annual rise in the number of patients presenting to the adult ED with suspected AAS. When compared with global incidences of AAS, the annual incidence in our ED was higher, although the underlying reasons for this difference remain unclear and warrant further exploration.

Acknowledgement

Open access publishing facilitated by The University of Auckland, as part of the Wiley - The University of Auckland agreement via the Council of Australian University Librarians.

Author contributions

SWFRW conceived the study and drafted the manuscript. SWFRW and SB collected data. All authors evaluated data and contributed to the manuscript.

Competing interests

PGJ is a section editor for *Emergency Medicine Australasia* and was therefore excluded from the peer review process and all subsequent editorial decisions related to the acceptance and publication of this article. Peer review was handled independently by members of the Editorial Board to minimise bias. The remaining authors declare no competing interests related to this work.

Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

References

1. Tsai TT, Nienaber CA, Eagle KA. Acute aortic syndromes. *Circulation* 2005; **112**: 3802–13.
2. Owens PL, Barrett ML, Gibson TB, Andrews RM, Weinick RM, Mutter RL. Emergency department care in the United States: a profile of national data sources. *Ann. Emerg. Med.* 2010; **56**: 150–65.
3. Goodacre S, Cross E, Arnold J, Angelini K, Capewell S, Nicholl J. The health care burden of acute chest pain. *Heart* 2005; **91**: 229–30.
4. Nazerian P, Mueller C, De Matos SA *et al*. Diagnostic accuracy of the aortic dissection detection risk score plus D-dimer for acute aortic syndromes the ADvISED prospective multicenter study. *Circulation* 2018; **137**: 250–8.
5. Hansen MS, Nogareda GJ, Hutchison SJ. Frequency of and inappropriate treatment of misdiagnosis of acute aortic dissection. *Am. J. Cardiol.* 2007; **99**: 852–6.
6. Lovy AJ, Bellin E, Levsky JM, Esses D, Haramati LB. Preliminary development of a clinical decision rule for acute aortic syndromes. *Am. J. Emerg. Med.* 2013; **31**: 1546–50.
7. Ohle R, Anjum O, Bleeker H, Wells G, Perry JJ. Variation in emergency department use of computed tomography for investigation of acute aortic dissection. *Emerg. Radiol.* 2018; **25**: 293–8.
8. Baliga RR, Nienaber CA, Bossone E *et al*. The role of imaging in aortic dissection and related syndromes. *JACC Cardiovasc. Imaging* 2014; **7**: 406–24.
9. Perotte R, Lewin GO, Tambe U *et al*. Improving emergency department flow: reducing turnaround time for emergent CT scans. *AMIA Annu. Symp. Proc.* 2018; **5**: 897–906.
10. Hagan PG, Nienaber CA, Isselbacher EM *et al*. The international registry of acute aortic dissection (IRAD). *JAMA* 2000; **283**: 897–903.
11. Von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP. The strengthening the reporting of observational studies in epidemiology (STROBE) statement: guidelines for reporting observational studies. *Ann. Intern. Med.* 2007; **147**: 573–7.
12. Lansman SL, Saunders PC, Malekan R, Spielvogel D. Acute aortic syndrome. *J. Thorac. Cardiovasc. Surg.* 2010; **140** (6 Suppl): S92–7.
13. Meng J, Mellnick VM, Monteiro S, Patlas MN. Acute aortic syndrome: yield of computed tomography angiography in patients with acute chest pain. *Can. Assoc. Radiol. J.* 2019; **70**: 23–8.
14. Wang TKM, Wei D, Evans T, Ramanathan T, Haydock D. Surgery for type A aortic dissection: 14-year contemporary cohort study. *Heart Lung Circ.* 2020; **29**: 1210–6.
15. Gupta AK, Subramaniam P, Hulme K, Vasudevan T. The sharp end of cardiovascular disease in New Zealand: a review of acute type a aortic dissections of the Waikato. *N. Z. Med. J.* 2015; **128**: 22–8.
16. Alter SM, Eskin B, Allegra JR. Diagnosis of aortic dissection in emergency department patients is rare. *West. J. Emerg. Med.* 2015; **16**: 629–31.
17. Rogers AM, Hermann LK, Booher AM *et al*. Sensitivity of the aortic dissection detection risk score, a novel guideline-based tool for identification of acute aortic dissection at initial presentation: results from the international registry of acute aortic dissection. *Circulation* 2011; **123**: 2213–8.
18. Pacini D, Di Marco L, Fortuna D *et al*. Acute aortic dissection: epidemiology and outcomes. *Int. J. Cardiol.* 2013; **167**: 2806–12.
19. Wundram M, Falk V, Eulert-Grehn J-J *et al*. Incidence of acute type A aortic dissection in emergency departments. *Sci. Rep.* 2020; **10**: 7434.
20. Dinh MM, Bein KJ, Delaney J, Berendsen Russell S, Royle T. Incidence and outcomes of aortic dissection for emergency departments in New South Wales, Australia 2017–2018: a data linkage study. *Emerg. Med. Australas.* 2020; **32**: 599–603.

21. Mészáros I, Mórocz J, Szlávi J *et al*. Epidemiology and clinicopathology of aortic dissection. *Chest* 2000; **117**: 1271–8.
22. Melvinsdottir IH, Lund SH, Agnarsson BA, Sigvaldason K, Gudbjartsson T, Geirsson A. The incidence and mortality of acute thoracic aortic dissection: results from a whole nation study. *Eur. J. Cardiothorac. Surg.* 2016; **50**: 1111–7.
23. Howard DPJ, Banerjee A, Fairhead JF *et al*. Population-based study of incidence and outcome of acute aortic dissection and premorbid risk factor control: 10-year results from the Oxford vascular study. *Circulation* 2013; **127**: 2031–7.
24. McClure RS, Brogly SB, Lajkosz K, Payne D, Hall SF, Johnson AP. Epidemiology and management of thoracic aortic dissections and thoracic aortic aneurysms in Ontario, Canada: a population-based study. *J. Thorac. Cardiovasc. Surg.* 2018; **155**: 2254–64.e4.
25. Yeh T-Y, Chen C-Y, Huang J-W, Chiu C-C, Lai W-T, Huang Y-B. Epidemiology and medication utilization pattern of aortic dissection in Taiwan. *Medicine* 2015; **94**: e1522.
26. Lee JH, Cho Y, Cho YH *et al*. Incidence and mortality rates of thoracic aortic dissection in Korea – inferred from the nationwide health insurance claims. *J. Korean Med. Sci.* 2020; **35**: e360.
27. Olsson C, Thelin S, Ståhle E, Ekbom A, Granath F. Thoracic aortic aneurysm and dissection: increasing prevalence and improved outcomes reported in a nationwide population-based study of more than 14,000 cases from 1987 to 2002. *Circulation* 2006; **114**: 2611–8.

Supporting information

Additional supporting information may be found in the online version of this article at the publisher's web site:

Appendix S1. STROBE Statement – checklist of items that should be included in reports of observational studies.