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Characteristics of reporting non-acute incidental abdominal aortic aneurysms

Quality study of actionable reporting

Master Thesis

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Abstract

Purpose
This thesis investigates radiological reports of incidental non-acute Aneurysma Aorta Abdominalis (AAA) findings in 2018. This entails the communication between the radiologists and the medical referrers written by radiologists in the radiological reports. A non-acute AAA is a clinically significant finding, that requires further action of the medical referrer, namely a follow-up ultrasound for the patient. In 2018, The Health and Youth Care inspectorate (IGJ) visited the Ziekenhuis Groep Twente (ZGT) and recommended to improve the communication about the non-acute incidental findings to prevent failure. This study aims to answer the following research question: How are non-acute incidental findings of the aortic abdominal aneurysms, detected by radiologic imaging techniques at Ziekenhuis Groep Twente, reported by radiologists in the radiological report to the referring medical specialist in 2018?

Methods
The search engine of the radiology department of Ziekenhuis Groep Twente (ZGT) was used to collect radiological reports of incidental abdominal aortic aneurysms. To determine the urgency of the incidental findings, different urgency constraints for AAA characteristics were defined to divide the incidental findings in the categories: acute, semi-acute and non-acute. The radiological reports were manually analyzed to collect reported clinical characteristics, and data about the structure and style used by the radiologist. The non-acute findings were divided into two subgroups: actionable and non-actionable findings. Actionability criteria were determined to measure the quality of communication between radiologists and the medical specialists. The quality was measured based on the adherence to the protocol of ZGT and the guideline of the Dutch Society for Radiologists (NVvR).

Results
In total, 179 radiological reports of incidental AAA findings were collected. AAA findings classified as non-acute were found in 157 of the 179 radiological reports. Of the non-acute, 92 were actionable findings and require nonroutine communication. Within 28 (17.8%) of the 157 radiological reports, the AAA findings were mentioned as incidental finding or reported in an incidental finding section. The most frequent reported clinical parameter was the size (88.5%). The report and conclusion section contained the incidental finding in 74 (84.7%) of the actionable and 44 (69.8%) of the non-actionable incidental AAA findings. Although the AAA finding location in the radiological report was not significantly different reported between actionable and non-actionable findings, a significant difference was found in reporting the size. Appropriate follow-up advice and nonroutine communication occurred for both in 13 (14.1%) of the actionable radiological reports.

Conclusion
The incidental finding in the conclusion section are not reported consistent nor in accordance with the protocol of the ZGT. Radiologists rarely contact the medical referring specialists if an incidental non-acute AAA finding is detected. This research shows that communication concerning non-acute findings is not according to the Dutch guideline 'Kritieke bevindingen' in ZGT. This result corresponds to the IGJ report. The quality of reporting and communication can therefore be improved to be more actionable.

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Preface

This thesis is the final product of my Master programme Health Sciences at the University of Twente. I started my graduation project at the Ziekenhuis Groep Twente (ZGT) radiology department in February 2019. I was really enthusiastic after reading the assignment description for this study. First, I was looking for a topic that was related to radiology because it had my interest. Second, I was inspired by the health sciences courses about quality in healthcare and motivated to investigate how a process could be improved. During this assignment I have learned many things about myself and in performing research. Research is not a step-wise process in practice, which I knew but had to experience.

I would like to gratefully acknowledge various people involved during this research as this work could not have been established without their help. First of all I owe a great deal of thanks to all my supervisors. I would like to thank all my supervisors as well for their feedback and time. Dr. A.T.M. Bellos Grob, thank you for stimulating me and to keep the focus in this research. I would like to thank Dr. M.M. Boere-Boonekamp who provided me guidence through the study design and insights in the writing process of this report. In addition, I would like to thank Dr. J.G. van Manen for her willingness to step in at the last moment and for providing feedback from a fresh point of view.

Secondly, this thesis was not possible without the help of ZGT providing the possibility to detect the radiological reports. Especially my thanks go out to the radiologists O. Vijlbrief, F. Wesseling and O. Kessels who provided insights in their daily work and clinical expertise of reporting.

Furthermore, I would like to thank my fellow Health Science students that were present at ZGT for the time we spend together and providing me help. Also, I want to thank my friends who have all showed their interest during this period and provided suggestions for improvements.

Finally, I want to thank my family and Remco for providing me with unfailing support and continuous encouragement throughout the process of researching and writing this thesis. This accomplishment would not have been possible without them. Thank you.

I hope you enjoy the reading of my thesis.

Marlies
November, 2019

Acronyms

AAA	Aneurysma Aorta Abdominalis
ACR	American College of Radiology
CT	Computer Tomography
MRI	Magnetic Resonance Imaging
NVvR	Dutch Society for radiologists
ZGT	Ziekenhuis Groep Twente
IGJ	The Health and Youth Care inspectorate

Glossary

Actionable findings Findings that require special communication with the referring medical specialist because of the critical character of the findings [1].

Actionability-criteria Criteria to determine the quality or state of the radiological report of being actionable for the referring medical specialist.

Acute findings Findings of category 1, are those that could lead to death or significant morbidity if not promptly recognized, communicated, and acted upon. Direct verbal communication to the referrer is generally required as promptly as possible (urgency of 'minutes') [1, 2, 3].

Aneurysm An aneurysm is a permanent localized dilation of an artery having at least a 50% increase in diameter compared to the expected normal diameter of the artery in question [4].

Communication log The reported communication details about the nonroutine communication between the radiologist and medical referring specialist.

Critical finding A finding in an imaging examination where a delay in reporting it, or a delay in or failure to become aware of the reporting thereof can result in serious adverse consequences for the patient, to be estimated by the evaluating radiologist. Both expected and unexpected findings can be critical. Critical findings require closed loop communication to ensure the referrer received the finding in time [2].

Ectasia Characterized by dilation less than 50% of the normal arterial diameter [4].

Incidental finding A finding arising from imaging without this being the direct question of the research [2].

Non-acute findings Findings of category 3, that generally do not require any immediate treatment or other action, but in the long term, they could be very significant (urgency of 'days'). These are often referred to as 'incidental' or 'unexpected'. Many of these findings will require follow-up imaging but, in some cases, not for many months [1, 2, 3].

Nonroutine communication Method of communication that is additional to the radiological report [1]. The communication with the reffering medical specialist about actionable findings could be directly (face-to-face, calling) or indirectly (attention mail, IT notification) [2, 3].

Non-actionable findings Findings that are radiologically known and require not additional nonroutine communication.

Patient with an AAA A person with an asymptomatic, symptomatic or ruptured AAA with a minimal diameter of 3.0 cm and the dilatation is fusiform [5].

Radiologically known finding A finding described in the radiological report that was compared with previous imaging information.

Semi-acute findings Findings of category 2. These are clinically significant observations that generally explain a patient's acute presentation. Specific medical or surgical treatment are required, but the urgency and severity is lower compared to those in category 1 (urgency of 'hours'). These findings will be communicated in the same manner as those in category 1 [1, 2, 3].

1 Introduction

Radiologists analyze many scans per day based on the indication of another medical specialist. The scans can be performed with imaging techniques such as Magnetic Resonance Imaging (MRI), Computer Tomography (CT), ultrasound and X-ray. Abnormalities without relation to the medical indication are often detected by radiologists. These types of findings are called 'incidental findings'. In a clinical setting radiologists define an incidental finding as a finding arising from imaging without this being the direct question of this research, as set by the Dutch Society for radiologists (NVvR) guideline [2]. The estimated frequency of incidental findings is almost one in four tests [6, 7].

Failures with negative effects for individual patients can occur during the different stages of reporting and communication between the radiologist and medical referrer. Therefore, preventing of failures concerning incidental findings is important [8]. This study focuses on the quality of reporting incidental non-acute Aneurysma Aorta Abdominalis (AAA) findings in the Ziekenhuis Groep Twente (ZGT).

Most incidental findings constitute a form of overdiagnosis of abnormalities that will never cause symptoms or death of the patient, but the detection can also be valuable when it is saving lives [9, 10]. Incidental findings can also be clinically significant findings which are potentially or definitely important and require additional work-up or follow-up [11, 12]. Approximately 4% to 25% of incidental findings are reported to be potentially significant and 5% to 11% are reported to be major and require immediate evaluation or intervention [12]. Incidental findings represent a significant risk to patients of failure to receive appropriate care or follow-up [1, 13]. The estimated frequency of clinical follow-up of incidental findings across all imaging modalities is only 65% [6, 7].

An AAA is defined as a local dilatation of the abdominal aorta which is larger than 3.0 cm [14, 15, 16, 17]. Large studies about incidental AAA findings, identified 0.5%-1.0% patients on abdominal images [18, 19]. Most aneurysms are asymptomatic and therefore often incidentally discovered on imaging with ultrasound, CT and MRI [10, 20]. A symptomatic patient can present with symptoms, especially pain and tenderness on palpation and is at increased risk for rupture [21, 22]. The prevalence of an AAA increases with age. About 1.5% of men in the Dutch population are estimated to have an AAA at the age of 65. An AAA is three to five times more common in men than women [20, 23]. Atherosclerotic plaque formation is thought to cause degenerative changes in the wall of the aorta, which can lead to loss of elasticity, weakening and dilatation [24, 25, 26].

An AAA finding is a clinically significant finding due to an indication for an ultrasound follow-up or an operation [5, 27, 28]. The study of Walraven et al. (2010) showed that the follow-up of patients with an incidental AAA appear to be poorly monitored. Of the patients who were observed after their first recommended follow-up scan, only 16% were monitored appropriately throughout their entire follow-up. Of the observed patients, 29% received no imaging follow-up at all [18]. The Health Council of the Netherlands advised an improvement of the Dutch healthcare in the monitoring of patients with incidental AAA findings in 2019 [20].

One key way how radiologists can add value to healthcare is by optimizing the impact of the radiological reports [29]. In 2017, the European Society of Radiology (ESR) mentioned that there is a consensus reached in the literature about the final characteristics: a good report should be timely, correct, complete and actionable [30, 31, 32, 33]. The concept of an actionable report is explained by Enzmann: radiologists can add value in the delivering of actionable information to referrers who are the decision makers of the patient [33]. To evaluate the quality of a radiological report according to the ESR, it is important to evaluate for completeness, accuracy, clarity, specificity, disease-based structure and adherence to guidelines [31]. Quality of reporting non-acute AAA findings is merely found in literature.

1.1 Problem definition

Currently, the ZGT uses a protocol to report incidental findings named *Onverwachte bevindingen*. According to the protocol of the ZGT, the incidental findings should be written in the report and conclusion section but it is unknown if this guideline is used and to what extent [3].

In 2015 the NVvR introduced a guideline named *Kritieke bevindingen*. The guideline of the NVvR describes that only an availability of the radiological report in the information system is insufficient for non-acute incidental findings: closed-loop communication of indirect or direct contact is necessary [2]. This guideline was an important step, especially for non-acute incidental findings, to improve the communication with the referring medical specialist.

In order to improve the communication about findings of the radiology department of the ZGT, the Health and Youth Care inspectorate (IGJ) visited the hospital and recommended to improve the communication of non-acute incidental findings in 2018 [34, 35]. The IGJ assessed the performance of the hospital and concluded the absence of closed-loop communication for non-acute incidental findings [35].

A fitting protocol in accordance with the NVvR guideline for non-acute findings is not implemented in ZGT. The guideline of the NVvR and protocol of the ZGT are not similar for non-acute findings and in the use of terminology. Only closed-loop communication with direct contact is described for incidental acute- and semi-acute findings in the protocol of the ZGT.

1.2 Aim of the study

The aim of this study is to provide more insight into the reporting and communication log between the radiologist and the medical referrer about non-acute incidental AAA findings in ZGT. The quality of the radiological reports with incidental findings will be analyzed by comparing these reports with the currently available protocol of the ZGT and guideline of the NVvR. Eventually, insights into current practice of reporting non-acute incidental findings can be used by the ZGT to improve the communication and follow-up of patients in the future.

1.3 Research Question

The research question is stated as follows: How are non-acute incidental findings of the aortic abdominal aneurysms, detected by radiologic imaging techniques at Ziekenhuis Groep Twente, reported by radiologists in the radiological report to the referring medical specialist in 2018?

To answer the main research question, the following sub questions will be answered:

1. What part of the incidental AAA findings is non-acute?
2. What part of the non-acute incidental findings is actionable?
3. What is the structure and style of reporting non-acute incidental AAA findings?
4. What clinical parameters of non-acute incidental AAA findings are included in the radiological report?
5. What is the difference of included actionability criteria between actionable and non-actionable non-acute incidental AAA findings?
6. What is the quality of the radiological reports based on the actionability criteria for non-acute AAA findings?

2 Theoretical Background

In this chapter the necessary background information about clinical guidelines and protocols will be provided. The topics are about the reporting and nonroutine communication by the radiologist towards a referring medical specialist, and the clinically significant AAA finding.

2.1 Reporting between the radiologist and referrer

The reporting of incidental AAA by the radiologists to referrers in ZGT is an important aspect in the work of a radiologist, because this is the main gateway of communication with the medical specialists [8, 30]. Due to voice recognition dictation systems, a fast transition to written text can be made automatically by the radiologist to create a report [36]. Currently, the format of a radiological report is a 'free-text report' and there are no universally accepted rules for the structure [29]. In general, the report contains a few basic elements with the following sections: indication i.e. the clinical referral, report i.e. the examination protocol with the description of radiological findings, and the conclusion to highlight the most important findings and an advice [29, 31]. In Figure 2.1, the reporting between the medical referrer and radiologist is schematically shown with the three main parts of the radiological report: indication, report and conclusion section.

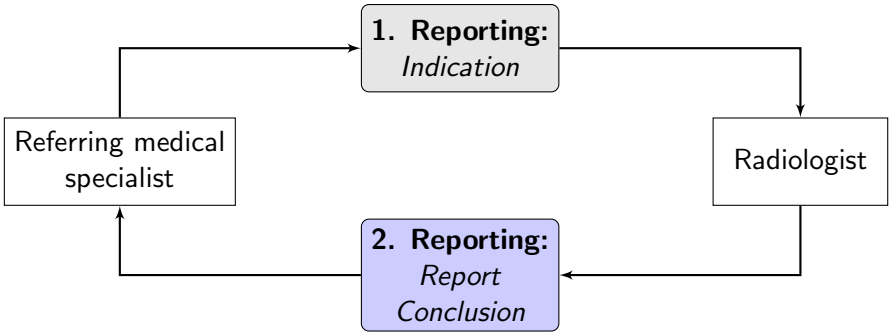

Figure 2.1: Schematic overview of reporting

A large number of referrers do not read the whole radiological report but only the conclusion [31]. According to the protocol of ZGT, non-acute incidental findings should be described in the report and conclusion. Besides, the finding should be reported within three days. [3]. Based on the ultrasound protocols of ZGT, the important reporting variables for the abdominal aorta are: size, level of the aneurysm in relation to the renal arteries, configuration i.e. the shape of the aneurysm, atherosclerosis and free peritoneal fluid [37, 38].

2.2 Communication process between the radiologist and referrer

It is the responsibility of the radiologists to write radiological reports. The referring medical specialist and the clinical team must read and act upon these findings. Effective and quick reporting and, quick acting by radiologists is crucial in this communication process [8].

2.2.1 Actionable findings

In 2014, the American College of Radiology (ACR) introduced the term 'actionable findings', which can be used as a general classification for findings that require special communication with the referring medical specialists [1]. In the guideline of the Dutch Association for Radiologists (NVvR), actionable findings are mentioned as critical findings (see Glossary).

The process of reporting and communication of actionable findings between the radiologist and referring medical specialist is schematically visualized in Figure 2.2. The nonroutine communication can be different types of direct or indirect contact and is characterized by a closed-loop to ensure that the referrer receives the finding [2, 3]. According to the Dutch guidelines, the

radiologist should report communication details about the contact with the referring medical specialist in the radiological report [2, 3]. This communication log must be mentioned after the conclusion [3].

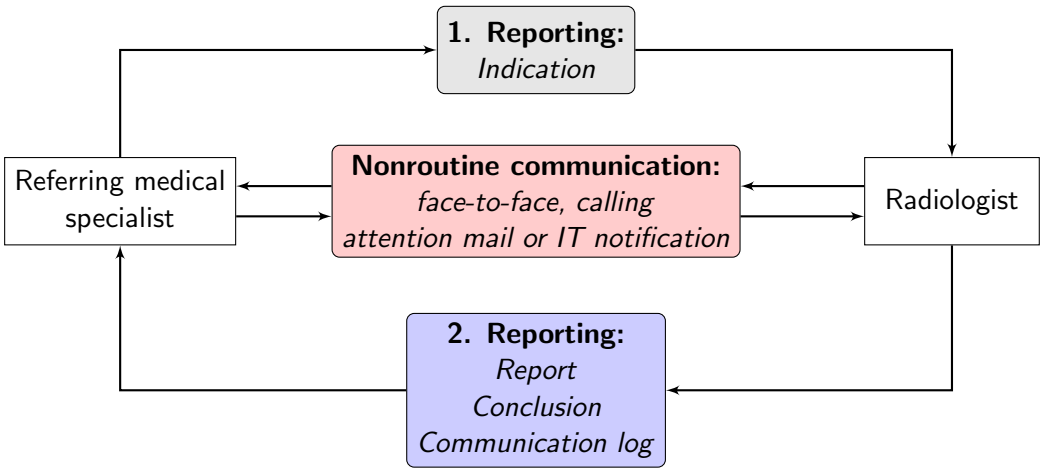

Figure 2.2: Schematic overview of closed-loop communication. After nonroutine communication, the radiologist reports a communication log about the contact with the referring medical specialist.

2.2.2 Urgency levels

Incidental findings are a special classification of findings and can require nonroutine communication. Findings and incidental findings can be classified in three categories of urgency: acute, semi-acute and non-acute. According to the urgency, the findings require communication and clinical decision within minutes (category 1), hours (category 2) or days (category 3) [1, 2, 3].

The ACR developed a list to illustrate the levels of urgency for different findings based on the critical character of the disease. In accordance with the critical character of AAA, the following classification of actionable findings is suggested by the ACR to illustrate the concept:

- Category 1: ruptured or leaking abdominal arterial aneurysm
- Category 2: abdominal aortic aneurysm $\geq$5.0 cm with no evidence of acute instability
- Category 3: abdominal aortic aneurysm $<$5.0 cm

Category 1 findings are the acute findings that could lead to death or significant morbidity if not promptly recognized, communicated, and acted upon with highest urgency [1, 2, 3].

Category 2 findings, the semi-acute findings, are clinically significant observations that generally explain a patient's acute presentation and require specific medical or surgical treatment [1].

Category 3 findings are the non-acute findings and generally do not require any immediate treatment or action, but can be significant on the long term [1, 2, 3]. An incidental finding is in general classified as an actionable finding category 3 if a longer term follow-up is required [1].

2.3 Abdominal Aortic Aneurysm criteria

In the ZGT, and according to the Dutch guidelines, a follow-up of an AAA is indicated if the diameter is between 3.0 cm and 5.5 cm. The interval period differs depending on the diameter of the AAA. The interval period can be three months (5.0-5.4 cm), a year (4.0-4.9 cm) or two (3.0-3.9 cm) years [5, 28].

According to the Dutch guideline, an operation is indicated if the AAA reaches a diameter of 5.5 cm for men, or 5.0 cm for women [5, 27]. For these large aneurysms, combined with a fast growth rate ($>$1.0 cm/year), radiologists should immediately and directly refer to a vascular surgeon for appropriate imaging and aneurysm repair [14].

3 Method

This chapter discusses the study design, units of observation, selection units of observation, data collection and analysis.

3.1 Study design

This research is an observational and quantitative study of retrospectively collected radiological reports of incidental non-acute AAA findings. These imaging findings were reported by radiologists in ZGT, at the radiology departments in Hengelo and Almelo in 2018. The ethical application for this study, with request number 190679 was approved by the Ethics Committee of the University of Twente in April 2019.

3.2 Units of observations

The units of observations in this study are radiological reports that contain incidental AAA findings. Instead of individual patients, radiological reports need to be analyzed on characteristics.

3.2.1 Definition of unit of observation

The definition of incidental findings as stated by the NVvR was used to collect the set of incidental findings: "A finding arising from imaging research without being the direct question of this research" [2]. Incidental AAA findings were classified as acute, semi-acute and non-acute. The non-acute AAA findings were divided into actionable and non-actionable findings. An overview of the data sets with collected incidental AAA findings is provided in Figure 3.1.

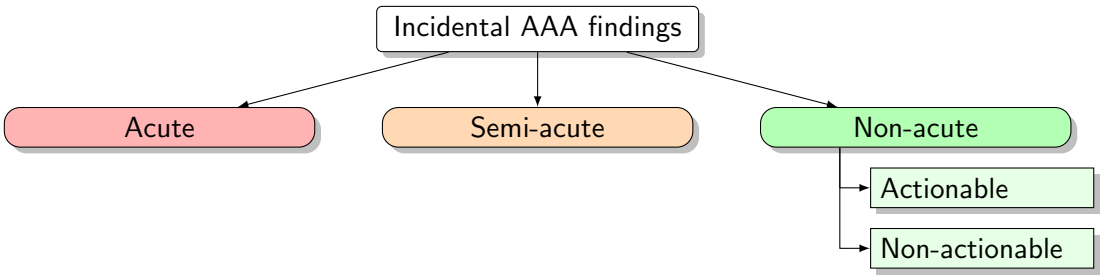

Figure 3.1: Classification of radiological reports that contain incidental AAA findings

3.2.2 Selection units of observation

The data for the analysis was collected with the PACS search engine of the ZGT. The radiological reports were collected with the search engine by using three different synonyms for an AAA, namely: *AAA*, *aneurysma aorta abdominalis* and *verwijde aorta abdominalis*. With the search engine it was possible to search for terms at different locations in the radiological report.

Two search strategies were applied (see Appendix A.1). The goal of the two search strategies was to collect all the radiological reports which mentioned one or more of the three different synonyms for AAA. The goal of the first search strategy was to determine the set of radiological reports without mention of the AAA synonyms in the conclusion section. In addition, the second search strategy collected the radiological reports that do mention the AAA synonyms in the conclusion. Both search strategies excluded the negation (i.e. *geen AAA*) of the synonyms in the radiological reports. Furthermore, radiological reports containing AAA in the indication were excluded to reduce the amount of radiological reports that were non-incidental. The resulting numbers of search strategy 1 and 2, and the usage of specific synonyms are displayed in Appendix A.2. With the search engine, a data set was created with possible incidental AAA findings.

The definition of the NVvR was applied for the exclusion of radiological reports that contained non-incidental findings. In total, four exclusion steps were taken to create a data set with only incidental AAA findings. The first two steps were based on the two variables *research number*

and *protocol number*. The third and fourth exclusion steps, necessitated detailed analysis of the clinical content in the radiological reports. The four main steps are displayed in Appendix B.1.

Exclusion criteria to collect the data set with incidental findings are described as:

- Duplicates of radiological reports
- Vascular scan, procedure or a control image in the abdominal region of the patient
- Imaging applied outside the non-abdominal and aortic region of the patient
- A direct abdominal vascular or AAA question in the indication of the radiological report
- Diagnosis of an AAA mentioned in the patient history of the indication
- Radiological reports that did not contain AAA findings
- Not clinically significant findings: small dilated and ectatic aorta findings

3.3 Data collection

From the included data set of radiological reports with incidental AAA findings, data on variables were obtained directly from the search engine or categorized in data for the analysis. The following clinical variables were collected to determine the part of non-acute, the clinical characteristics and reported clinical parameters (sub question 1 and 4):

- Size of the aneurysm, categorical based on the advised guidelines for follow-up: 3.0-3.9 cm, 4.0-4.9 cm, 5.0-5.4 cm, absent
- Configuration, i.e. the shape of the aneurysm: fusiform, saccular, both, absent
- Anatomical location: infrarenal, juxtarenal, suprarenal, absent terminology
- Symptomatic AAA described by the radiologist: yes, no
- Gender: women, men
- Age: $<$65, 65-80, $\geq$80 year
- Imaging modality: X-ray, MRI, ultrasound, CT
- Unique patient: yes, no

The following variables were collected to determine which part of the findings is radiologically known to conduct the part of non-acute and actionable findings (sub question 1 and 2). Figure 3.2 schematically shows the new and radiologically known findings.

- Degree of confidence in the diagnosis: mentioned directly *bekend*, indirectly radiologically known, mentioned suspicion (new), unexpected finding based on the indication (new)
- Mentioned suspicion: yes, no
- Mentioned known: yes, no
- Aneurysm growth: stable, growth, absent
- Radiologically known: yes, no
- Previous date
- Previous size

Findings were categorized as radiologically known based on a performed scan comparison and reporting of previous information by the radiologist. A scan comparison means comparing a previous scan with the current scan of a patient done by the radiologist. The reported information could contain data about the previous date and size of the aneurysm compared with the current diameter. The findings that were directly mentioned as known and/or indirectly categorized as stable or growth were classified as radiologically known (see Appendix D.1). The findings that were mentioned as a suspicion or could not be classified as radiologically known were categorized as new.

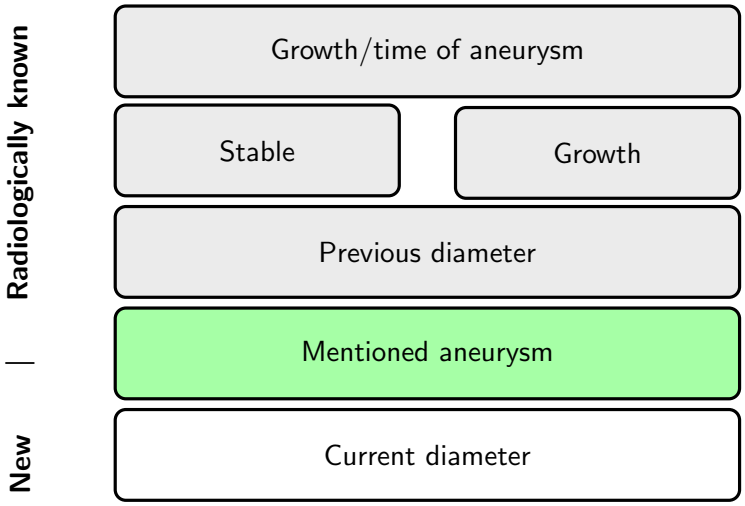

Figure 3.2: Levels of information depth about new and radiologically known AAA findings in the radiological report.

The constraints that determined the urgency of AAA were defined for an AAA finding and can be found in Appendix D.2. The urgency constraints were applied by using the clinical and radiologically known variables that were collected. The following recoding variables determine the urgency and what part of the non-acute findings were actionable (sub question 1 and 2):

- Urgency constraints: 1.1 till 3.8 (Appendix D.2)
- Urgency of the finding: acute, semi-acute and non-acute

The radiological reports were recoded by applying the ascending numerically order of the constraints on the data set and resulted in a division of categories: acute, semi-acute and non-acute AAA findings. The classification of urgency was based on literature [1], policy of the hospital and was approved by a radiologist of the ZGT. The following definitions of urgency were used:

- Acute findings are those that could lead to death or significant morbidity if not promptly recognized, communicated, and acted upon (urgency constraints: 1.1 till 1.2).
- Semi-acute findings are clinically significant observations that generally explain a patient's acute presentation and require specific medical or surgical treatment (urgency constraints: 2.1 till 2.5).
- Non-acute findings do not require any immediate treatment or action, but in the long term, they could be very significant (urgency constraints: 3.1 till 3.8).

The following constraints for non-acute AAA findings were used: $\geq$3.0 cm, no CTA or operation was indicated ($<$5.0 cm for women, $<$5.5 cm for men), growth of $<$1.0 cm/year and radiologically known or new findings.

After determining the part of non-acute AAA findings in sub question 1, further analysis was executed only for the non-acute findings. For all non-acute findings it was determined whether they were actionable or not. The following definitions were used:

1. Actionable findings are defined as findings that require nonroutine communication. The findings are (suspected to be) new or were significantly worsened since a prior study and require further action and follow-up [1].

2. Non-actionable findings are defined as findings that do not require additional nonroutine communication if the findings were previously known. It was assumed that these findings were already appropriately communicated and do not require further action [1].

The findings that were classified as actionable contain one of the following characteristics: new, significantly worsened ectasia or mentioned as a suspicion for AAA. Subgroups with constraints

3.1 till 3.5 (see Appendix D.2), were therefore classified as actionable. The findings that were radiologically known, did not require additional nonroutine communication and were classified as non-actionable. Subgroups with constraints 3.6 till 3.8 (see Appendix D.2) were therefore assumed to be non-actionable findings.

The following variables were collected to determine the structure and style of the radiological reports (sub question 3):

- Number of words in the report and conclusion: <100, 100-249, 250-399, 400-650
- Structure of incidental finding: mentioned within report section, mentioned within conclusion section, section below report section, section below conclusion section, absent
- Incidental finding section: yes, no
- Structure of incidental finding section: summary, numbered list, list of items, absent
- Structure of conclusion section: summary, numbered list, list of items, absent

The following 'actionability variables' were collected to determine the frequency of the actionability criteria in the conclusion part (sub question 5 and 6):

- Reported communication details between the clinical referrer and radiologist: yes, no
- Communication details about contact person, date, time and type: yes, no
- Location of the aneurysm description in the radiological report: report, conclusion, both
- Location of the size of the aneurysm in the radiological report: report, conclusion, both, both (unequal), absent
- Advice: ultrasound follow-up, consult vascular surgeon, review EPD, no advice, additional research other findings

The quality of a radiological report was defined by the actionability criteria and determines how 'actionable' radiological reports were for the referring medical specialist. The classification of actionable and non-actionable findings was used to measure the actionability criteria. The actionability criteria are divided in four 'reporting' and two 'nonroutine communication' criteria. The following actionability criteria (a-f) were measured in frequency by the actionability variables and related quality indicators.

Actionability criteria

Reporting:

a. Non-acute AAA findings are reported and available for the referring medical specialists within three days [3].
b. The AAA finding is described in the report and conclusion [3].
c. Size of the AAA should be included in the conclusion, because this is the most important clinical parameter to determine the urgency [10].
d. The radiological report should include in the conclusion appropriate clinical advice for the AAA finding on the next step of management, to ensure timely clinical decisions for patients [8, 39].

Nonroutine communication:

e. Radiologists who detect non-acute incidental AAA findings should alert referrers with a local mechanism, this communication should be reported [2, 8].
f. The following communication details are reported in the communication log: name or function of the contact person, date, time and method of communication [2].

The quality outcome was measured with the frequency of five quality indicators (sub question 6):

1. Reporting within three days
2. Finding in conclusion part
3. Size in conclusion part
4. Appropriate follow-up advice
5. Nonroutine communication

The adherence to the protocol of ZGT was measured by 'reporting within three days' and 'finding in conclusion part'. The quality indicator 'nonroutine communication' measured the adherence to the Dutch NVvR guideline. The quality of nonroutine communication and appropriate follow-up advice were only measured for actionable findings.

3.4 Data analysis

The collected variables were extracted from the definitive radiological reports and were further categorized manually with Microsoft Access 2016. This program enables collection of the data with the designed forms and building the database. Recoding of the data set was also done in Microsoft Access 2016.

Tableau 2018 was used to explore the database and to correct irregularities in the data set. Calculations and further data analysis with the Pivottable function were done in Microsoft Excel 2016. Statistical Package for Social Sciences (SPSS) version 25 was used for descriptive statistics and analyzing data between two subgroups. Descriptive statistics were used to analyze the numerical and categorical variables. For originally numerical variables, the mean and standard deviation (SD) were included if categorical data was provided. For the categorical variables, the number of radiological reports and percentages of the different data sets were provided. The Pearson's Chi-Square test was done to perform subgroup analysis. The Fishers Exact test was done, if the assumption of minimum expected cell frequencies was violated for the Chi-Square test. For both tests, two sided p values were used and a $p < 0.05$ indicated statistically significant results.

4 Results

In total, 179 radiological reports of incidental AAA findings are included in this study from the period 1-1-2018 till 31-12-2018. The radiological reports contain one of the following terms: *AAA* (60.9%), *aneurysma aorta abdominalis* (25.7%), *verwijde aorta abdominalis* (12.3%) or a combination of the terminology (1.1%). From all the available radiological reports in this timeframe, the detection rate is nearly 0.1% (179/225,979). Table 4.1 displays the 179 radiological reports of non-acute incidental AAA findings that are included in this study.

Table 4.1: Included incidental AAA findings (N = 179)

	Incidental AAA findings							
	Total		**Non-acute**		**Actionable**		**Non-actionable**	
	N = 179		N = 157		N = 92		N = 65	
Characteristics	No.	%	No.	%	No.	%	No.	%
Urgency AAA finding								
Acute	2	(1.1)						
Semi-acute	20	(11.2)						
Non-acute	157	(87.7)	157	(100)				
Actionable								
New					90	(97.8)		
Significantly worsened					2	(2.2)		
Non-actionable								
Radiologically known							65	(100)
Primary imaging reasons								
Tumor staging/control	35	(19.6)	31	(19.7)	13	(14.1)	18	(27.7)
Back pathology	30	(16.8)	25	(15.9)	18	(19.6)	7	(10.8)
Suspicion malignancy	28	(15.6)	26	(16.6)	18	(19.6)	8	(12.3)
Follow-up abnormality	26	(14.5)	26	(16.6)	12	(13.0)	14	(21.5)
Urological pathology	25	(14.0)	21	(13.4)	14	(15.2)	7	(10.8)
Gastro-intestinal complaints	19	(10.6)	13	(8.3)	5	(5.4)	8	(12.3)
Pulmonal complaints	6	(3.4)	5	(3.2)	4	(4.3)	1	(1.5)
Trauma	4	(2.2)	4	(2.5)	4	(4.3)	-	
Residue	4	(2.2)	4	(2.5)	2	(2.2)	2	(3.1)
Unknown	2	(1.1)	2	(1.3)	2	(2.2)	-	

4.1 Non-acute incidental AAA findings

In this section, the first sub question will be answered: What part of the incidental AAA findings is non-acute? In total, 157 (87.7%) of the incidental AAA findings are non-acute, as can be seen in Table 4.1. From all the available abdominal radiological reports in this period, the detection rate of the non-acute incidental findings is 0.5% (157/30,172[1]). Details about the subdivision to acute, semi-acute and non-acute findings are shown in Appendix D.3.

4.2 Non-acute actionable and non-actionable findings

In this section, the second sub question will be answered: What part of the non-acute incidental AAA findings is actionable? The division of non-acute incidental AAA findings resulted in 92 (58.6%) actionable findings and 65 (41.4%) non-actionable findings. In Table 4.1, this division is displayed based on the findings that are radiologically known, significantly worsened and new. Of the 157 non-acute AAA findings, 67 (42.7%) are classified as radiologically known based on the

[1]Number based on the production data of abdominal scans in 2018 at the ZGT.

comparison with previous imaging. The part classified as significantly worsened consists of two AAA findings that were previously known as an ectasia. In total, 90 (57.3%) of the non-acute findings could not be classified as radiologically known and are therefore new.

For actionable findings, further work-up or ultrasound surveillance could be the following steps for the patient that needs to be initiated by the referring medical specialist. The difference with the non-actionable findings is that further steps of action have already been taken for the patient.

4.2.1 Patient and clinical characteristics related to radiological reports

Table 4.2, displays the patient, clinical and structure characteristics of the 157 radiological reports that contain non-acute AAA findings. The patient population is smaller than the number of included non-acute AAA findings in the radiological reports. In total, 141 unique patients are included in this study of 157 radiological reports. The majority of the patients is between 65 and 80 years (63.7%). AAA findings are predominantly detected in men (84.7%). The majority of the 157 incidental non-acute AAA findings are detected by radiologists from patients who received a CT (51.6%).

In total, 73 (46.5%) AAA findings are between the 3.0-3.9 cm. The ranges for the actionable findings that contain new AAA findings resulted in the following division: 7 (7.6%) are indicated for an ultrasound surveillance within 3 months, 25 (27.2%) are indicated for a follow-up within one year and 50 (54.3%) within two years. In 10 (10.9%) of the radiological reports, the size is unknown, for this group the indicated follow-up period is unknown.

4.3 Structure and style of reporting incidental AAA findings

This section will answer the third sub question: What is the structure and style of reporting non-acute incidental AAA findings? The results of the structure and style are provided in this chapter for each section in the radiological report of the 157 non-acute AAA findings. The length of a radiological report can varies considerably. The report and conclusion contain an average of 183 words (SD: 82 words) for non-acute findings (see Table 4.2). Within 27 (17.2%) radiological reports, the findings are mentioned as *nevenbevinding* (in English incidental finding) or reported in an incidental finding section.

4.3.1 The report and conclusion section

In all the report sections, the findings were summarized in an order that depends on the used strategy of the radiologist when analyzing the scan. The conclusion sections usually followed after the report sections. From the 157 radiological reports, 150 (95.5%) contained a conclusion section. Of the 150 radiological reports, 99 (66.0%) AAA findings were reported in a conclusion section and 20 (13.3%) below in the incidental finding section. The AAA findings in the conclusion section were summarized by the radiologists in 44.4% (44/99), in 43.4% (43/99) included in a list of items and in 12.1% (12/99) included in a numbered list.

4.3.2 Incidental findings section

In total, 24 (15.3%) radiological reports mentioned AAA findings in a separate section for incidental findings (displayed in Table 4.2 and 4.3). In 12.7% (20/157), the incidental finding section was located below the conclusion section. Details of the incidental finding section are displayed in Table 4.3. An AAA finding described below a report or conclusion section, in an incidental findings section, is further on in this study considered as a part of the report or conclusion.

Table 4.2: Patient, clinical and structure characteristics of included radiological reports that contain incidental non-acute actionable and non-actionable AAA findings (N = 157)

	Radiological reports with a non-acute AAA finding					
	Total		**Actionable**		**Non-actionable**	
	(n = 157)		(n = 92)		(n = 65)	
Characteristics	No.	(%)	No.	(%)	No.	(%)
Gender[a]						
Women	24	(15.3)	17	(18.5)	7	(10.8)
Men	133	(84.7)	75	(81.5)	58	(89.2)
Age[a]						
mean (SD)	75 (7)		75 (8)		75 (7)	
<65 year	16	(10.2)	10	(10.9)	6	(9.2)
65-80 year	100	(63.7)	54	(58.7)	46	(70.8)
≥80 year	41	(26.1)	28	(30.4)	13	(20)
Imaging modality						
X-ray	20	(12.8)	15	(16.3)	5	(7.7)
MRI	13	(8.3)	6	(6.5)	7	(10.8)
Ultrasound	43	(27.4)	19	(20.7)	24	(36.9)
CT	81	(51.6)	52	(56.5)	29	(44.6)
AAA Size[a]						
mean (SD)	3.9 (0.8)		3.8 (0.7)		4.2 (0.8)	
3.0-3.9 cm	73	(46.5)	50	(54.3)	23	(35.4)
4.0-4.9 cm	46	(29.3)	25	(27.2)	21	(32.3)
5.0-5.4 cm	20	(12.7)	7	(7.6)	13	(20.0)
Absent	18	(11.5)	10	(10.9)	8	(12.3)
Mentioned known[b]						
Yes	38	(24.2)	-		38	(58.5)
No	119	(75.8)	92	(100)	27	(41.5)
Specified stable/growth[b]						
Yes	46	(29.3)	2	(2.2)	44	(67.7)
No	111	(70.7)	90	(97.8)	21	(32.3)
Mentioned suspicion						
Yes	9	(5.7)	9	(9.8)	-	
No	148	(94.3)	83	(90.2)	65	(100)
Length report and conclusion						
mean (SD)	183 (82)		189 (86)		170 (73)	
<100 words	39	(24.8)	25	(27.2)	14	(21.5)
100-249 words	84	(53.5)	45	(48.9)	39	(60.0)
250-399 words	28	(17.8)	18	(19.6)	10	(15.4)
400-650 words	6	(3.8)	4	(4.3)	2	(3.1)
Incidental finding section						
Yes	24	(15.3)	16	(17.4)	8	(12.3)
No	133	(84.7)	76	(82.6)	57	(87.7)

[a] Patient characteristic of the radiological report that is not corrected for individual patients

[b] Characteristic of a radiologically known finding

Table 4.3: Structure and style of the incidental finding section (N = 24) located below report section ($n = 4$) and below conclusion section ($n = 20$)

	Incidental finding section		
Location	Style	No.	(%)
Below report section ($n = 4$)	Summary	4	(16.7)
Below conclusion section ($n = 20$)	Summary	14	(58.3)
	Numbered list	4	(16.7)
	List of items	2	(8.3)

4.4 Clinical AAA parameters

This section answers the fourth sub question: What clinical parameters of non-acute incidental AAA findings are included in the radiological report? The results are collected to provide more transparency in how detailed the characteristics of the AAA finding was reported by the radiologists in the radiological report. The frequency of the parameters and their categories are displayed in Table 4.4.

Table 4.4: Clinical parameters of non-acute incidental AAA findings mentioned in the radiological report (N = 157)

	Non-acute AAA findings	
Clinical parameters	No.	(%)
Size		
Mentioned	139	(88.5)
Not mentioned	18	(11.5)
Configuration		
Fusiform	5	(3.2)
Absent terminology	152	(96.8)
Location		
Infrarenal	40	(25.5)
Juxtarenal	1	(0.6)
Suprarenal	1	(0.6)
Absent terminology	115	(73.2)

The size of the aneurysm, based on measurements in scans of different imaging modalities, is mentioned in 139 (88.5%) radiological reports. Radiologists reported the size of non-acute AAA findings in the following descending order of the imaging modality: CT in 100% (81/81), ultrasound in 95.3% (41/43), MRI in 84.6% (11/13), and X-ray in 30% (6/20). In 5 (3.2%) radiological reports, the configuration of the AAA finding was mentioned with terminology as fusiform. In 42 (26.8%) radiological reports the location of the aneurysm was mentioned with terminology in relation to the renal arteries.

4.5 Frequency of actionability criteria

This section answers the fifth sub question: What is the difference of included actionability criteria between actionable and non-actionable non-acute AAA incidental findings? To answer this question, the results are provided by a comparison between actionable and non-actionable findings based on the actionability criteria. A distinction was made in the actionability criteria for reporting and nonroutine communication and also for the results in this section. The frequencies for the two subgroups of the 157 non-acute AAA findings are displayed in Table 4.5 and 4.6 for the different actionability variables (a-f).

4.5.1 Reporting

In total, 74 (84.7%) of the actionable and 44 (69.8%) non-actionable AAA findings were reported in the report and conclusion part. No significant difference was found between the two groups ($p = 0.059$).

The majority, 65 (70.7%) of the radiological reports with actionable AAA findings contain an aneurysm size in the report and conclusion part versus 27 (41.5%) for the non-actionable. The size of actionable AAA findings was significantly more often reported in both parts compared to non-actionable findings (p <0.001).

For actionable AAA findings, two different advises were provided for further work-up of the AAA findings: in 7 (7.6%) radiological reports the advice was an ultrasound follow-up and in 6 (6.5%) a consult with a vascular surgeon. Nearly all the findings with an ultrasound advice were mentioned as a suspicion for AAA. The advice for further work-up of the AAA findings was a bit higher for actionable findings, although no significant result was found.

4.5.2 Nonroutine communication

Table 4.6 and 4.7 displays that 14.1% of the radiological reports with actionable findings contain a communication log with communication details. No significant difference was found between the actionable and non-actionable findings. The communication log was always added below multiple findings in the conclusion of the radiological report and was not specific for the AAA finding. The type of communication about the AAA finding for the actionable findings occurred six times directly by phone and three times indirectly with an attention mail. The results about the details of nonroutine communication are displayed in Table 4.5.

Table 4.5: Reported details about nonroutine communication for the actionable and non-actionable findings (N = 18)

	Total ($n = 18$)		**Actionable** ($n = 13$)		**Non-actionable** ($n = 5$)		***p*-value**
Actionability variable	No.	%	No.	%	No.	%	
(f.) Details nonroutine communication							0.382[a]
Name or function contact person	10	(55.6)	8	(61.5)	2	(40.0)	
Date	9	(50.0)	7	(53.8)	2	(40.0)	
Time	8	(44.4)	7	(53.8)	1	(20.0)	
Method of communication	11	(61.1)	9	(69.2)	2	(40.0)	

[a] Fisher's Exact test; $p \geq 0.05$

Table 4.6: Actionability variables of non-acute incidental AAA findings (N = 157)

		Total (n = 157)		**Actionable** (n = 92)		**Non-actionable** (n = 65)		***p*-value**
Actionability variables		No.	%	No.	%	No.	%	
(a.)	Duration availability radiological report							0.259[b]
	Same day	138	(87.9)	84	(91.3)	54	(83.1)	
	After one day	12	(7.7)	6	(6.5)	6	(9.2)	
	After two days	6	(3.8)	2	(2.2)	4	(6.2)	
	Three days or more	1	(0.6)	0	(0)	1	(1.5)	
(b.)	Location(s) finding							0.059[b]
	Report	38	(24.2)	17	(14.1)	21	(30.2)	
	Conclusion	1	(0.6)	1	(1.2)	0	(0)	
	Report and conclusion	118	(75.2)	74	(84.7)	44	(69.8)	
(c.)	Location(s) aneurysm size							0.000[a]
	Report	44	(28.0)	15[a]	(16.3)	29[a]	(44.6)	
	Conclusion	2	(1.3)	1	(1.1)	1	(1.5)	
	Report and conclusion	92	(58.6)	65[a]	(70.7)	27[a]	(41.5)	
	Report and conclusion; unequal	1	(0.6)	1	(1.1)	0	(0)	
	Absent	18	(11.5)	10	(10.9)	8	(12.3)	
(d.)	Reported advice							0.136[b]
	US follow-up	8	(5.1)	7	(7.6)	1	(1.5)	
	Consult vascular surgeon	7	(4.5)	6	(6.5)	1	(1.5)	
	Review EPD	4	(2.5)	1	(1.1)	3	(4.6)	
	No advice	120	(76.4)	67	(72.8)	53	(81.5)	
	Additional research; non-specific AAA	18	(11.5)	11	(12.0)	7	(10.8)	
(e.)	Nonroutine communication							0.161[c]
	Yes	18	(11.5)	13	(14.1)	5	(7.7)	
	No	139	(88.5)	79	(85.9)	60	(92.3)	

[a] Fisher's Exact Test; (4, n = 157) = 17.330, p <0.001
[b] Fisher's Exact test; $p \geq 0.05$
[c] Pearson's Chi-Square; $p \geq 0.05$

4.6 Quality of the radiological reports

This section answers the sixth sub question: What is the quality of the radiological reports based on the actionability criteria for non-acute AAA findings? The quality indicators in Table 4.7 provides an overview of the quality outcomes for non-acute and the subgroup of actionable findings. The actionable findings are the new and significantly worsened non-acute AAA findings that require ultrasound follow-up and nonroutine communication.

Nearly all the non-acute findings were reported within three days after the date of imaging and were available in time for the referring medical specialist. In total, 119 (75.8%) of the non-acute findings were reported in the conclusion according to the protocol of ZGT. Of the actionable findings, 13 (14.1%) of the radiological reports contained follow-up advice for an ultrasound or a consult with a vascular surgeon. According to the Dutch guideline, actionable non-acute incidental findings require nonroutine communication that should be reported in a communication log. In total, 13 (14.1%) of the radiological reports that contain actionable non-acute AAA findings mentioned the contact with the referring medical specialist.

Table 4.7: Quality indicators of reported non-acute AAA findings and communication with the referring medical specialist

	Non-acute findings (N = 157)	
Quality indicators	No.	%
Reporting within three days[a]	156	(99.4)
Finding in conclusion part[a]	119	(75.8)
Size in conclusion part	95	(60.5)
	Actionable findings (*n* = 92)	
Quality indicators	No.	%
Appropriate follow-up advice	13	(14.1)
Nonroutine communication[b]	13	(14.1)

[a] Protocol ZGT
[b] Guideline NVvR

5 Discussion

In this discussion section a summary of the main results is provided. Further the results of the six sub questions will be discussed and compared to the literature, and strengths and limitations will be mentioned.

5.1 Summary of main results

This study collected 179 radiological reports of incidental AAA findings in 2018. Of the radiological reports that contain incidental AAA findings, 157 non-acute findings were divided in 92 (58.6%) actionable and 65 (41.4%) non-actionable. In the conclusion part of the radiological report was a small part of the non-acute AAA findings structured in an incidental finding section. The most frequent reported clinical parameter was the AAA size. Only a significant difference was found in reporting of the AAA size between actionable and non-actionable findings. According to the protocol of ZGT, incidental findings were in 75.8% reported in the conclusion part of the radiological report. This implies that radiologists relatively inconsistent reported the finding in the conclusion to the medical specialists. An appropriate follow-up advice based on the measured size was often not provided in the radiological report. Radiologists rarely contact the medical specialists in the case of non-acute incidental AAA findings. Only in 14.1% of the radiological reports, actionable findings were communicated by phone or an attention mail to the referring medical specialist.

5.2 Comparison with earlier studies

From all the available abdominal radiological reports in this period, the detection rate of the non-acute incidental findings is 0.5% in ZGT. The found incidence of incidental non-acute AAA findings could not be compared with large follow-up studies such as Al-Thani et al. (2014) and Walraven et al. (2010) [18, 19]. The most important reason is that incidental AAA findings of individual patients were collected instead of radiological reports. The study-design of Al-Thani et al. (2014) found an incidence of 0.5% and was limited to the detection of incidental AAA findings of patients who received CT. The study-design of Walraven et al. (2010) found an incidence of 1.0% and excluded radiological reports if patients were familiar with an AAA.

A relatively large amount of the non-acute AAA findings were non-actionable (41.4%), which were also previously detected. An explanation for this result was that more findings could be detected by the increased availability and more advanced imaging techniques [20, 40]. Also, an aneurysm of 3.0 cm takes on average 10 to 12 years before there is an operation indication [20]. So the chance is relatively high that the finding is already known and multiple times is detected.

Non-actionable findings were also classified as radiologically known and often mentioned as known (58.5%). It is unknown what a possible effect is for mentioning the finding as known for the interpretation of the medical referrer. The reporting of a non-actionable finding can result in an underestimation of importance for the medical referrer if the finding was previously overlooked and follow-up failed. Although, a known finding could also extra alert a medical referrer to verify if the diagnose was also included in the patient history and if appropriate action was taken. In the case of radiologically known findings, it could be challenging for the radiologists to provide 'actionable' information to the medical specialists. A possible found effect was a more extensive reporting by the radiologists about a comparison with previous imaging.

This study found a small amount of radiological reports (12.7%) with a structured incidental finding section. The reporting style of the section where the incidental finding was mentioned, was often a summary. The variations in a structured incidental findings section and reporting style could be explained by individual preferences of radiologists [31].

Mainly, only the size is specified in the reporting of an AAA. The size is reported relatively accurately in 88.5% of the radiological reports. The quality of the scan can be a cause for a

missing AAA size, because it made the radiologists unable to measure the size. Although the frequency of mentioning the size could be influenced by the type of imaging modalities, it could be deduced that radiologists see the importance for further patient management and action for the referring medical specialist.

The current protocol in ZGT describes to report incidental AAA findings in the report and conclusion section [3], this occurs for actionable findings (84.7%) more than non-actionable findings (69.8%). This results in a relatively high amount of radiological reports without mentioned findings in the conclusion. The methodology used by radiologists to report incidental findings can be influenced by personal knowledge assembled during training, practice experience and exposure to literature or guidelines [33]. Based on the findings, two explanations could explain the inconsistency of reporting according to the protocol of ZGT. First of all, it is possible that radiologists do not classify the finding as incidental or non-acute. That could result in an inconsistent reporting of the findings in the conclusion without taking the protocol into account. Moreover, in this study it is found that a relatively low number of findings are mentioned as incidental finding (17.8%). Secondly, a confusion in terminology might explain why non-actionable findings were less frequently reported in both sections [1, 6]. The protocol of ZGT is using the term *onverwachte bevindingen* (Dutch instead of English) for unexpected findings. This term is broad and can be confusing in the case of radiologically known findings for radiologists. Because non-actionable findings are all radiologically known AAA, it could be interpreted that the findings are thus 'expected findings' and that the protocol is not applicable. This explanation can be supported by the frequency of reporting the size in the conclusion. The size of actionable AAA findings was reported significantly more in both parts of the radiological report than the size of non-actionable findings, 70.7% versus 41.5%. Mentioning the size and finding in the conclusion could be seen as less important, if radiologists suppose that the patient is already referred for an ultrasound follow-up.

What was rather unexpected for the actionable findings was that only in 14.1% an advice was reported for additional ultrasound research or a referral to a vascular surgeon. The result is not in line with the quality standard of an actionable radiological report that should contain advice [39]. In addition, a previous study evaluates the preference of medical specialists to include information about imaging follow-up or recommendations for additional imaging. The study found a strong evidence that the information should be included [41]. No clear reason was found why radiologists in a very low amount provide advice because, it could be very important in further patient management. A possible explanation could be that radiologists trust the expertise of medical referrers to decide, based on the diagnose and/or abnormal size, that a referral is indicated according to the vascular protocol of ZGT.

According to the Dutch guidelines of the NVvR [2], the non-acute actionable incidental findings require nonroutine communication with the medical specialists that should be reported. Only in a small part of the radiological reports with actionable findings (14.1%), communication details were reported. This outcome corresponds with the IGJ report for non-acute AAA findings that closed-loop communication was applied insufficient in ZGT [34, 35]. The mentioning of contact was probably based on the urgency of other described findings in the conclusion. Because, the part of radiological reports that mentioned nonroutine communication was for both actionable and non-actionable findings very small. Also, the incidence in the literature of incidental acute and semi-acute findings is between 5% to 11% [12]. A previous study of Gordon et al. (2009) also found a low frequency in the communication of AAA findings (5%) and corresponds with the guideline of the NVvR and IGJ report that only reporting is insufficient [2, 34, 42].

An incidental finding was often reported simultaneously to many other (incidental) findings that could have influenced the reporting and communication by radiologists. Walraven et al. (2010), found that medical specialists infrequently reported and communicated the incidental AAA findings and monitoring plans for a hospitalized patient to the general practitioner. Medical specialists could have overlooked the AAA findings that were identified at imaging due to the indications or treatments of other serious and acute findings [18].

5.3 Strengths and limitations

A strength of this study is the systematical data collection based on the definition of the NVvR for incidental findings. The search strategies have resulted in a representive data set of radiological reports with non-acute incidental AAA findings. In addition, a high amount of reporting characteristics of the radiologists were analyzed.

A first limitation of this study is the division of non-acute incidental AAA findings that could not be perfect due to the following reasons: absence of a standardized classification model [20], limited amount of expertise and missing values due to the reported information by the radiologists. Although it was desirable that more than one radiologist confirmed the classification, this was not realized. Nevertheless, it was possible to design classification criteria on specific clinical characteristics that were probably very complete to determine the incidence of non-acute findings. For a small part, values of the current and previous aneurysm sizes were missing. The effect on the quality outcomes was limited because the analyzed findings were incidental and AAA findings are by definition larger than 3.0 cm. An aspect on patient level were the described complaints in the indication, that could also indicate an acute finding because the patient could have a symptomatic AAA. If the radiologists did not mention the finding as symptomatic, it was assumed that the complaints were related to other findings. The mentioned reasons may have led to an overestimation of non-acute findings.

A second limitation in this study was the effect of case-mix due to the different aneurysm sizes and indicated follow-up duration. It could have influenced the reporting by radiologists and the quality outcomes of the non-acute findings. Therefore, it is possible that patients who were indicated for a follow-up interval of three months were reported differently, compared to patients with a follow-up of one or two years.

A third limitation in this study was that it could not be verified what the reason was why radiologists mentioned findings as known and if the patient was already in a follow-up. The findings could be radiologically known based on reported information about previous imaging, but also on other information in the EPD. For the classification of non-actionable findings it would have been more reliable to use information about the patient history.

A fourth limitation in this study was the interpretation of the Dutch NVvR guideline. The NVvR guideline states that critical findings, which can cause serious adverse consequences for the patients if not adequately communicated, require closed-loop communication [2]. This study interpreted based on the NVvR guideline that closed-loop communication is required to communicate all actionable AAA findings that need a first follow-up action. Because, additional communication of these findings can prevent serious adverse consequences for the patients. However, there can be argued that the guideline can be interpreted in a different way. Therefore, the interpretation of the NVvR guideline may have caused a bias.

A fifth limitation was the relatively small sample size of the collected radiological reports and a limited amount of time for data collection due to the manual process. This could be improved by a better algorithm to detect the radiological reports. A larger data set could provide more statistical power, especially for the reported locations of the incidental actionable and non-actionable findings. Also, the division into two subgroups and the high variation in reporting resulted in some small samples with a frequency lower than five. This could have influenced the statistical power if the Fishers Exact test was used instead of the Pearson's Chi-Square Test due to the violated assumption of minimum expected cell frequencies. Meanwhile, the variation of data collection in this study provides important qualitative insights in the reporting of incidental non-acute AAA findings.

6 Conclusion and clinical implications

In this study, the following aspects were found that can lead to a delay or a missed ultrasound follow-up for the patient:

1. A large amount of findings can result in an unstructured lengthy radiological report. Incidental AAA findings are sometimes only briefly mentioned. Usually, only the sizes of these findings are specified. A possible consequence can be that the findings are easily overlooked by the medical specialist.
2. When the findings are not reported and communicated according to the quality standards, it can occur that the medical referring specialist overlooks the AAA findings. Because there is evidence that a large number of referrers do not read the whole radiological report but only the conclusion, it is possible that the finding is missed.

This study emphasizes the importance of reporting and communicating the incidental findings according to the quality standards as set by the guideline of the NVvR and protocol of ZGT. In the ZGT, incidental AAA finding in the conclusion are not reported consistent nor in accordance with the protocol of the ZGT. Also, this study found that the communication of non-acute AAA findings was not sufficiently followed according to the Dutch guideline '*Kritieke bevindingen*'. In conclusion, the quality outcomes of this study provide more insight into current practice and shows that the reporting and communication of non-acute incidental AAA findings should be improved.

Reporting
Both the free-reporting style and protocol of ZGT, results in a non-standardized method of reporting non-acute findings and often lack providing advice in the conclusion. The radiological reports can be more actionable for referring medical specialist if the AAA finding, size and an advice is reported in the conclusion. To get a more standardized method, the current ZGT protocol and reporting template can be improved for the radiologists. For example, a structured incidental finding section can result in a more systematically method of reporting the finding in the conclusion. A section for incidental actionable findings focusses the attention of the medical specialists about findings that require action. Moreover, the detection of radiological reports with incidental findings could also be easier and enables future research with larger data sets.

Nonroutine communication
The current protocol of ZGT is not adapted to the Dutch quality standards for communication of non-acute findings. Although the ZGT is working on the implementation that meets the criteria of closed-loop communication, a solution and adapted protocol is not implemented yet for non-acute incidental findings. Closed-loop communication between the radiologist and medical specialist could enlarge an adequately monitoring and a timely operation for the patient with an AAA. An effective workflow, without any delays or missing results, could reduce acute scenario's of rupture in the future and could be life-saving for patients. The quality of patient care could be improved by a notification system that is linked to the EPD and requires a confirmation of action from the medical specialist to close the loop. In contrast to acute and semi-acute findings, it should be avoided that medical specialists are interrupted with a phone call for non-acute findings. It is recommended to implement an alert system for non-acute incidental findings that requires a short or long term follow up.

Future research
For non-acute AAA patients that are delayed or missed for an ultrasound follow-up, it is important to retrospectively analyze and detect potential failures in reporting and communication of findings. To implement an effective system that leads to uniform communication of incidental non-acute AAA findings by radiologists at ZGT, more research on different incidental findings is necessary. For a revision of the protocol for closed-loop communication of non-acute findings, the preferences of radiologists and medical specialists are very important to take into account

and the impact must be evaluated. In essence, future research is important to evaluate the added value of closed-loop communication and effectiveness in the follow-up of patients.

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A Search matrices

A.1 Applied search strategies

For applying the following two search strategies, the following aspects are important for interpretation:

1. The synonyms that were used for the search strategies are A/B/C [in Dutch]:
   A = *AAA*, B = *Aneurysma Aorta Abdominalis* and C = *verwijde aorta abdominalis*.
2. The synonyms that are used for the negative forms of AAA are A*/B*/C* [in Dutch]:
   A* = *geen AAA*, B* = *geen Aneurysma Aorta Abdominalis* and C* = *geen verwijde aorta abdominalis*.
3. Each search strategy was applied three times for one of the three synonyms (6 samples in total).
4. With the PACS search engine it was possible to search for terms in the final report, the indication and conclusion. The search engine was limited to five search fields and the functions AND and NOT were applied.
5. The final report was the definitive radiological report that also contained, besides the indication and conclusion, the report section. The data of the 'final report' was more complete than the separate indication and conclusion.

A.1.1 Parameters strategy 1

Table A.1: Synonym A/B/C not mentioned in the conclusions of the radiological reports

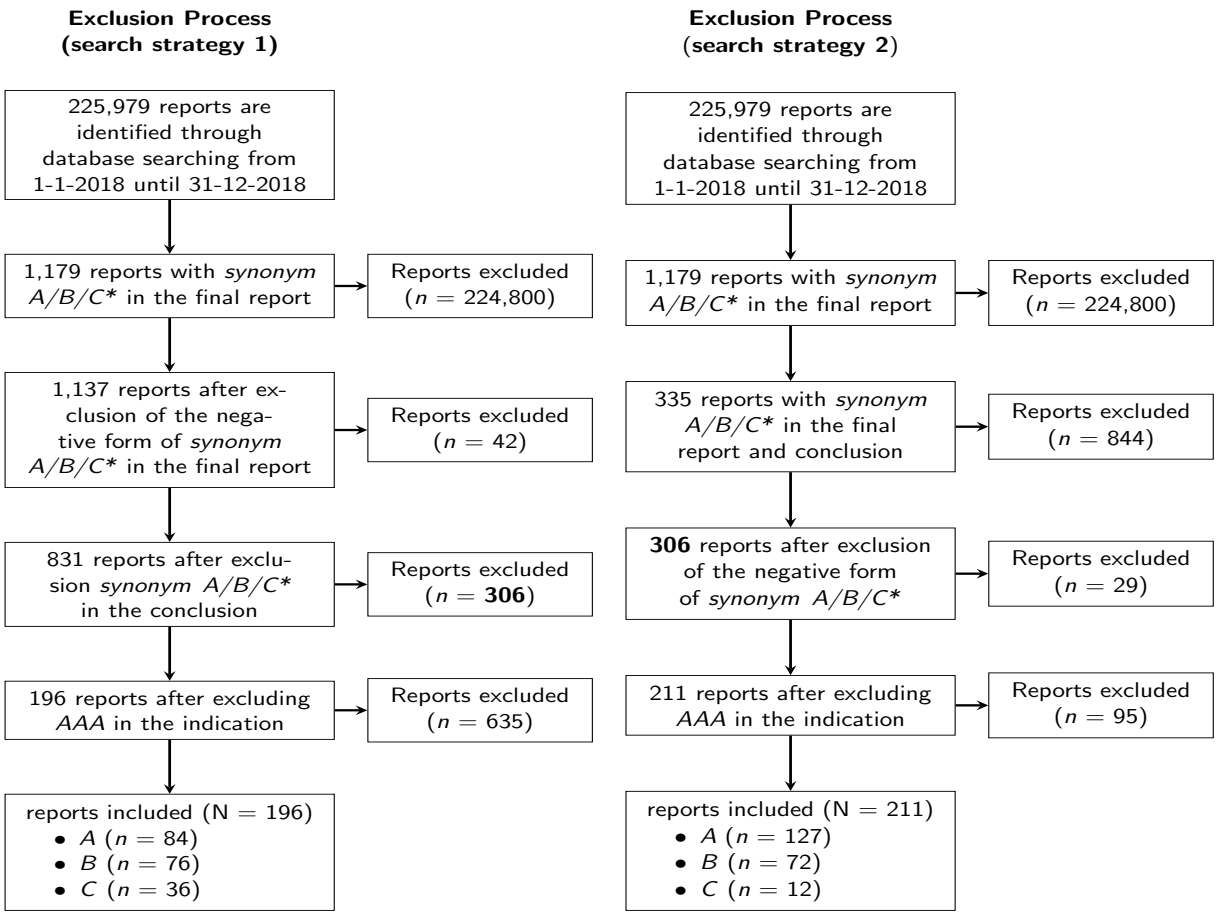
Search terminology	Indication	Final report	Conclusion
2018	-	Inclusion	-
A/B/C	-	Inclusion	Exclusion
A*/B*/C*	-	Exclusion	-
A	Exclusion	-	-

A.1.2 Parameters strategy 2

Table A.2: Synonym A/B/C mentioned in the conclusions of the radiological reports

Search terminology	Indication	Final report	Conclusion
2018	-	Inclusion	-
A/B/C	-	Inclusion	Inclusion
A*/B*/C*	-	Exclusion	-
A	Exclusion	-	-

A.2 Additional results search engine



(a) Flow diagram of included radiological reports with the synonyms not mentioned in the conclusions of 2018

(b) Flow diagram of included radiological reports with the synonyms mentioned in the conclusions of 2018

*Synonyms: A = *AAA*, B = *aneurysma aorta abdominalis* and C = *verwijde aorta abdominalis*

Figure A.1: Flow diagram of the exclusion process with the PACS search engine with data dating from 2018

A.2.1 Before duplicate correction

Table A.3: Synonyms in the radiological reports before duplicate correction

	Included 2018	
Synonyms	(n = 407)	%
AAA	211	(51.8)
Aneurysma aorta abdominalis	148	(36.4)
Verwijde aorta abdominalis	48	(11.8)

A.2.2 After exclusion non-incidental AAA

Table A.4: Synonyms in the radiological reports of incidental and non-acute AAA findings

	Total incidental findings		**Total non-acute findings**	
Synonyms	(n = 179)	%	(n = 157)	%
AAA	109	(60.9)	96	(61.2)
Aneurysma aorta abdominalis	46	(25.7)	37	(23.6)
Verwijde aorta abdominalis	22	(12.3)	22	(14.0)
Mix of synonyms	2	(1.1)	2	(1.3)

B Flow diagram of incidental AAA findings

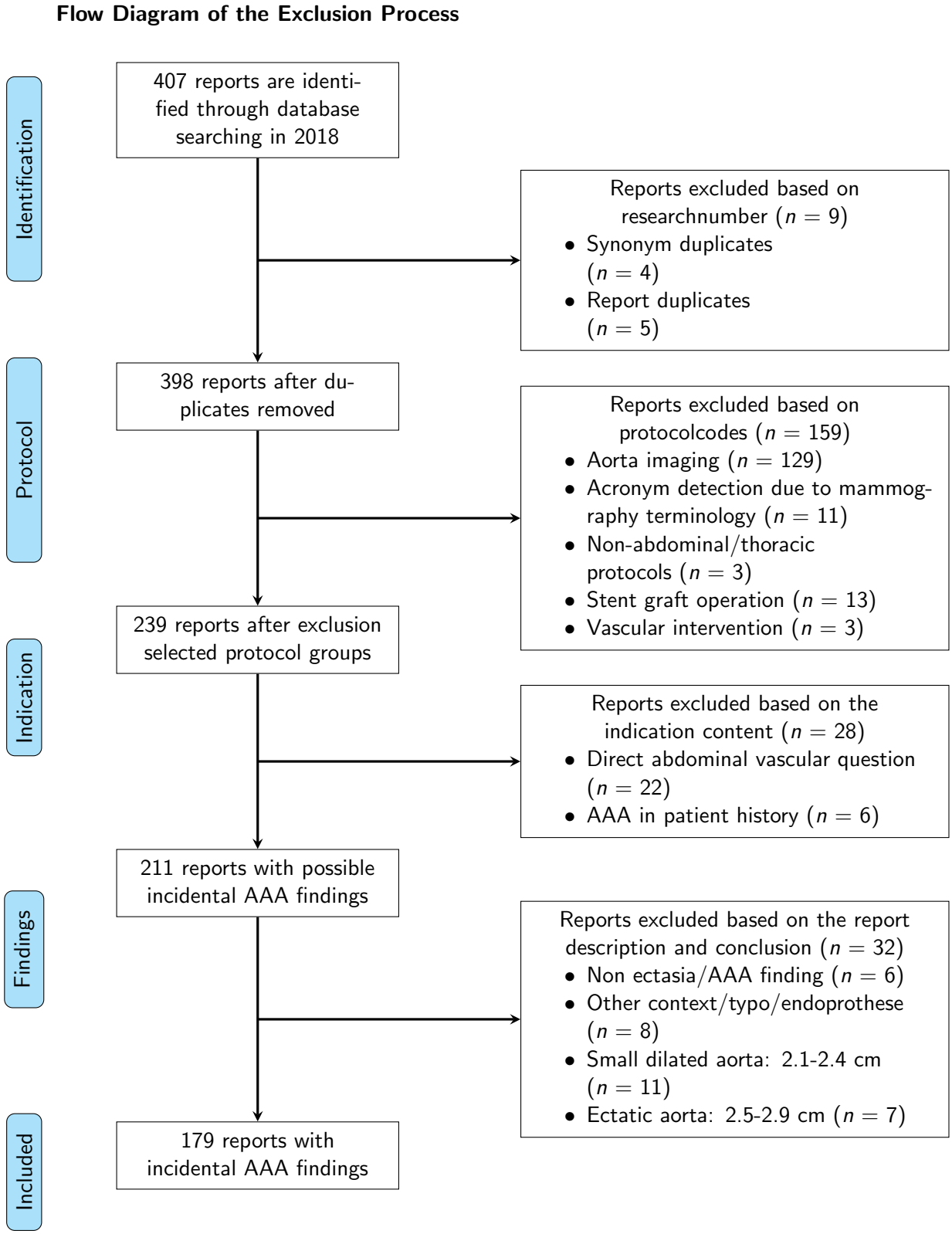


Figure B.1: Flow diagram of data set with incidental AAA findings of 2018

C Exclusion of protocol groups

Table C.1: Exclusion of protocols for five subgroups with a Dutch translation of the protocols (N = 159)

Exclusion of protocols		**No.**
Exclusion 1: Aorta imaging		
E7-25	*Echo aorta (abdominalis)*	61
C7-30	*CTA aorta*	45
F7-26	*Duplex aorta iliaca bdz (bloedvaten van de buik)*	15
F7-27	*Duplex aorta iliaca bdz-duplex been art. bdz*	3
F7-28	*Duplex aorta iliaca bdz-duplex been art. rechts*	1
F7-29	*Duplex aorta iliaca bdz-duplex been art. links*	4
Exclusion 2: Acronym detection		
69-02B	*Mammografie follow up bdz*	5
69-01B	*Mammografie beiderzijds*	4
69-05B	*Mammografie mammapoli beiderzijds*	1
69-02L	*Mammografie follow up links*	1
Exclusion 3: Non-abdominal/thoracic protocols		
M9-30R	*MRI knie rechts*	1
E9-02L	*Echo lies links*	1
E2-02	*Echo hals*	1
Exclusion 4: Post-operative aneurysm		
V0-60	*Stent graft ok*	13
Exclusion 5: Vascular intervention		
V0-31B	*PTA + stent nier beiderzijds*	1
V0-35R	*PTA art. fem. superficialis rechts*	1
V0-90	*PTA op OK*	1

D Recoding of the radiological reports

D.1 Categorization of radiologically known findings

Table D.1: Characteristics of radiologically known findings in relation to mentioning the AAA finding. Some mentioned known findings could also be categorized as stable or growth.

Term(s) in radiological report	Literal English translation	Categories
Directly known		
Bekend(e)	Known	Mentioned known
Indirectly known		
Conform	Conform	Stable
Ongewijzigd	Unchanged	Stable
Onveranderd	Unchanged	Stable
Toename	Increase	Growth
Nu .. cm, was .. cm	Now [size], was [size]	Growth
t.o.v. eerder	Compared to earlier	Growth
Ten opzichte van	Relative to	Growth
Toegenomen	Increased	Growth
Gegroeid	Grown	Growth
Progressief	Progression	Growth
Vermeerderde	Increased	Growth

D.2 Constraints to determine the urgency

Urgency constraints

Category 1: Acute

1.1 Major complication: leaking or potential rupture [1, 14]
1.2 Suspicion for a symptomatic AAA

Category 2: Semi-acute

2.1 Significant aneurysm growth ($\geq$1.0 cm/year [14] or $\geq$0.5 cm/half year)
2.2 Minor complication: suspicion periaortitis [5]
2.3 Saccular aneurysm [5]
2.4 Size of AAA $\geq$5.0 cm for women (indication for CT Angiography/operation) [14, 27, 28]
2.5 Size of AAA $\geq$5.5 cm for men (indication for CT Angiography/operation) [14, 28]

Category 3: Non-acute

Actionable findings:

3.1 General: Suspicion for an AAA
3.2 New/unexpected aneurysm; 3.0-5.0 cm for women [28, 5]
3.3 New/unexpected aneurysm; 3.0-5.5 cm for men [28, 5]
3.4 New/unexpected aneurysm; size unknown
3.5 Growth ectasia to an AAA ($\geq$3.0 mm [5], $<$ 1.0 cm/year)

Non-actionable findings:

3.6 Growth AAA ($\geq$3.0 mm [5], $<$ 1.0 cm/year)
3.7 Stable aneurysm
3.8 Known AAA that is not further classified

D.3 Additional results of recoding

Table D.2: Incidental AAA findings (N = 179) with the classification to acute, semi-acute and non-acute findings based on the subdivision

Incidental	**Subgroups**		
AAA findings (N = 179)	Constraint	No.	(%)
Acute (N = 2)			
leaking/potential rupture	1.1	1	(50)
symptomatic	1.2	1	(50)
Semi-acute (N = 20)			
significant progression	2.1	1	(5)
suspicion periaortitis	2.2	2	(10)
saccular aneurysm	2.3	4	(20)
operation/CTA indication (♀)	2.4	4	(20)
operation/CTA indication (♂)	2.5	9	(45)
Non-acute (N = 157)			
suspicion	3.1	9	(5.7)
new (3.0-5.0 cm, ♀)	3.2	13	(8.3)
new (3.0-5.5 cm, ♂)	3.3	64	(40.8)
new (size unknown)	3.4	4	(2.5)
growth ectasia to AAA	3.5	2	(1.3)
growth	3.6	10	(6.4)
stable	3.7	34	(21.7)
known (not classified)	3.8	21	(13.4)