ORIGINAL ARTICLE

Prevalence, pathological outcomes and cardiometabolic associations of adrenal incidentalomas: A single-center experience in Saudi Arabia

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Abstract

Background: Non-adrenal imaging can detect Adrenal Incidentalomas (AI). Due to enhanced and widespread imaging in clinical settings, adrenal tumours are commonly identified incidentally and raise crucial considerations about malignancy and hormone production. *Aim and Objectives:* Two-year retrospective research to investigate the prevalence of AI in non-adrenal CT images was done. The second objective was to determine the pathogenic AI subtype and hormonal hypersecretion. Final objective was to assess AI patients' cardiometabolic risk variables. *Material and Methods:* A retrospective observational study was conducted to review all eligible chest, abdominal, pelvic and Kidneys, Ureters, and Bladder (KUB) CT scans done for non-adrenal causes. Statistical Package for the Social Sciences was used for data analyses, and chi square and Fisher's exact test were used to assess associations where appropriate. *Results:* Study showed a 4% prevalence of AI in people aged 31-83 years. Reviews of CT scans showed 85.7% of AI in abdomen and 14.3% in thorax. Majority were unilateral (mean size of 1.78cm, and average density -3.8 HU). Of all AI patients, cardio-metabolic risk assessment showed 73.8% as having Diabetes Mellitus (DM)/pre-DM, 64.3% as hypertensive, 52.8% were obese, 66.7% had high low density lipoprotein cholesterol, 16.7% had elevated triglycerides. A statistically significant gender-wise association ($p < 0.05$) was found between male AIs patients and cardio-metabolic risk factors. *Conclusion:* AIs can have serious clinical implications. Hormonally active or malignant AIs need quick detection and treatment through policies that improve interdisciplinary communication and set consistent procedures for ensuring timely appropriate referral of incidental adrenal findings for endocrine testing and further follow-ups.

Keywords: Adrenal Incidentaloma, Tomography, Cardiometabolic Risk Factors, Retrospective Study, Saudi Arabia

Introduction

Adrenal Incidentalomas (AIs) are adrenal masses larger than 1 cm that are found during imaging for non-adrenal diseases [1,2]. In recent years due to better and easily available imaging techniques, the diagnosis of asymptomatic adrenal lesions has increased [3]. AI occurs in 2.3% of autopsy studies, increasing from 0.2% in young to 6.9% in the elderly [4]. These incidentalomas may be benign, malignant, or extra-adrenal metastases. Fewer than 5% of AIs are cancerous, while the majority are benign and non-functional [5]. Tumour size, size stability on interval imaging and lipid composition serve as important indicators in distinguishing benign from malignant tumours. A 4 cm cutoff limit is used to distinguish malignant from benign lesions [6]. Unenhanced Computed Tomography (CT) attenuation below 10 Hounsfield unit (HU) differentiates lipid-rich benign adenomas from non-

adenomatous lesions. Benign AI usually doesn't require additional imaging, but if malignant or has indeterminate features, CT wash-out or Magnetic Resonance Imaging (MRI) in-phase/out-of-phase scans should be performed [7].

Approximately 12–15% of adrenal tumours exhibit hormonal hyperactivity, resulting in clinical or subclinical presentations associated with aldosteronism, Cushing's syndrome, or pheochromocytoma [8]. Diseases like Diabetes Mellitus (DM), dyslipidemia, and hypertension can appear even if classic signs of Cushing's syndrome are absent, because of Autonomous Cortisol Secretion (ACS) [9,10,11]. Resolution of these conditions may occur after surgical excision of the AI [12]. The Overnight Dexamethasone Suppression Test (ODST) categorizes patients as normal (am cortisol < 1.8 µg/dl), mild ACS (am cortisol 1.9–5.0 µg/dl), or definite ACS (am cortisol > 5 µg/dl) [9,10,12].

AI, insulin resistance/Metabolic Syndrome (MeS) and obesity constitute an interrelated triad. Metabolic dysfunction stimulates adrenal receptors, leading to AI development. Conversely, AI induced ACS increases IR by enhancing hepatic gluconeogenesis [13]. This dysregulation of the adipocytokine pathway in MeS, along with the direct effects of adipokines on the adrenal gland, may underlie adipose–adrenal "cross-talk" [14, 15]. This interaction may increase the risk of hypertension, diabetes, obesity, and dyslipidemia, thereby linking AIs to higher cardiovascular risk [16]. Moreover, elevated cortisol levels stimulate the renin-angiotensin system, resulting in increased concentrations of norepinephrine and cardiac angiotensin II, which contribute to cardiac dysfunction. High levels of cortisol also cause oxidative stress, damage the endothelium, and promote fibro-proliferation, thus altering the structure and function of the heart and blood vessels [16,17]. AI patients are classified according to guidelines, facilitating initial diagnosis and decisions regarding further management [12].

Global data exists on AI prevalence, diagnosis and management, regional information for different population groups remains scanty. It is unclear whether patients in Saudi Arabia are properly evaluated for incidentalomas or what outcomes they face in terms of malignancy, hormonal excess, and cardiometabolic disease. Keeping these in view, this study examined the prevalence of AIs in the Saudi population by retrospectively analyzing routine chest, abdominal, and pelvic CT scans performed for non-adrenal indications. Radiological imaging and endocrine tests available in the patients' records were used to detect AI-related subtypes. Moreover, the research observed how the pathogenic subtypes of AIs were related to other cardiometabolic risk factors, including obesity, dyslipidemia, pre-DM, hypertension, and DM. The research findings may be used to help develop regional policies to guarantee that all AI cases found by radiologists are promptly reported to concerned specialties.

Material and Methods

After getting approval from the Institute's Research Board (IRB), a retrospective observational study was carried out at a secondary care hospital in Jubail. The research was planned in collaboration with the radiology department and endocrine outpatient clinic. A consecutive sampling technique was used to include all eligible CT scans that were done for adults above 18 years, who had a chest, abdomen, pelvis, or Kidneys, Ureters, and Bladder (KUB) scan done for non-adrenal reasons from January 1, 2021, and December 31, 2022 and therefore no sample size calculation was done. The research period was restricted to two years to ensure

that a sufficient number of CT scans could be reviewed and relevant clinical records could be accessed and assessed. Patients with hormonal profile anomalies having adrenal imaging for suspected adrenal lesions were excluded. Due to ethical concerns, all AI cases missed in the initial radiology report were sent to concerned specialists. Patient identities were kept anonymous and used just for the study. After IRB and departmental approvals, the researcher and radiologist reviewed CT scans in the Picture Archiving and Communication System (PACS).

For patients with AI imaging abnormalities, medical records were reviewed to assess investigations and outcomes. Lab results were reviewed to assess the hormonal profile of patients whose radiological records suggested AI. A positive test for aldosteronism was defined as an Aldosterone to Renin (A:R) ratio more than 3.7 ng/dL/μIU/ml. In order to differentiate between normal and suspected mild ACS, a threshold of < 176 μg/24 hr for 24-hour Urine-Free Cortisol (UFC) was used. A threshold of > 1.8 μg/dl was used to differentiate mild ACS from normal levels in the ODST. Metanephrine/normetanephrine screening ruled out pheochromocytoma by employing a cutoff criterion twice the normal values (normal: < 25 pg/ml for metanephrine and < 148 pg/ml for normetanephrine). Malignant potential and metastasis were assessed with further imaging.

Cardio-metabolic risk variables, such as hypertension, DM, pre-DM, obesity, and dyslipidemia, were assessed in persons with non-functional AI, mild ACS-associated AI (functional AI), aldosteronism, and pheochromocytoma to assess their prevalence.

Patients with blood pressure exceeding 140/90 mm of Hg or on antihypertensive therapy were considered as hypertensive. patients with glycosylated haemoglobin (HbA1c) level above 6.5% or were already taking treatment for DM were considered as diabetics. Pre-diabetes was defined as HbA1c between 5.7% and 6.4% or impaired fasting glucose above 6.1 but below 7 mmol/l. Patients were classified as obese if their Body Mass Index (BMI) was above 30 kg/m², overweight if between 25 and 29.9 kg/m², and normal if less than 25 kg/m². Dyslipidemia was determined based on diabetes, age, heart disease risk, LDL-C and triglyceride values, and all patients using lipid-lowering medication. We used a checklist/proforma to collect all relevant data anonymously and confidentially.

Statistical Package for the Social Sciences version 22 was used for data analyses. Quantitative variables (age, size, and tumor density) were expressed as mean ± standard deviation, whereas qualitative variables (AI present or absent, cardiometabolic risk factors, hormonal evaluation, gender, and age categories) were expressed as frequencies and percentages. Descriptive statistics such as frequency and percentages were used to identify AI and cardiometabolic risks. Pearson's chi-square test at 5% significance was used to see if cardiometabolic risk variables and types of AI based on hormonal evaluation were related.

In cross-tabulations where the expected count in the cell was less than 5 in one or more than one cell, Fisher's exact test at a 5% level of significance was applied to determine association. A value of $p < 0.05$ was considered statistically significant. Missing values were reported as 'not done' or 'unknown' (Table 3, 4 and 5), and analyses were done without any imputation using available data for relevant variables.

Results

Prevalence and demographic profile of patients with adrenal incidentaloma

A total of 1,036 CT scans were reviewed, revealing an AI prevalence of 42 (4.05%; 95% CI: 2.96%–5.43%). Figure 1 shows the number of scans identified and their referral for endocrinology evaluation. Among the 42 scans, 61.9% were males and 38% were females. Patients diagnosed with AI had a mean age of 58.07 ± 12.9 years, with an age range of 31–83 years. The incidence of AI was greater among those over the age of 40 (Figure 2).

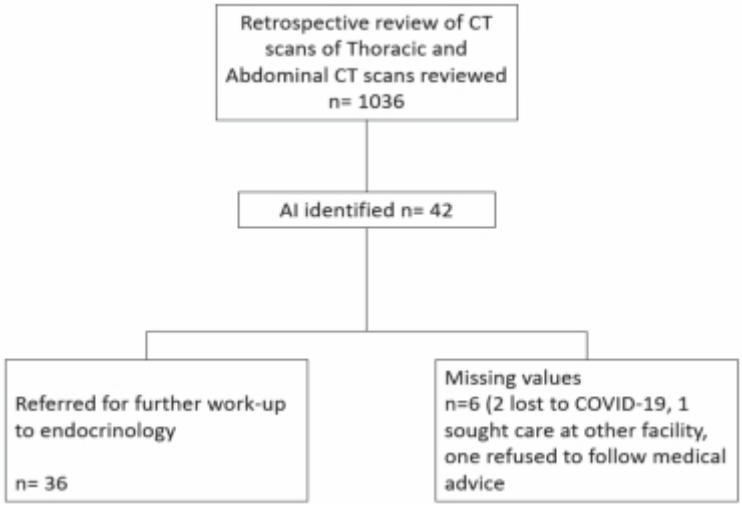

Figure 1: AI case identification

CT – computed tomography; AI – adrenal incidentalomas

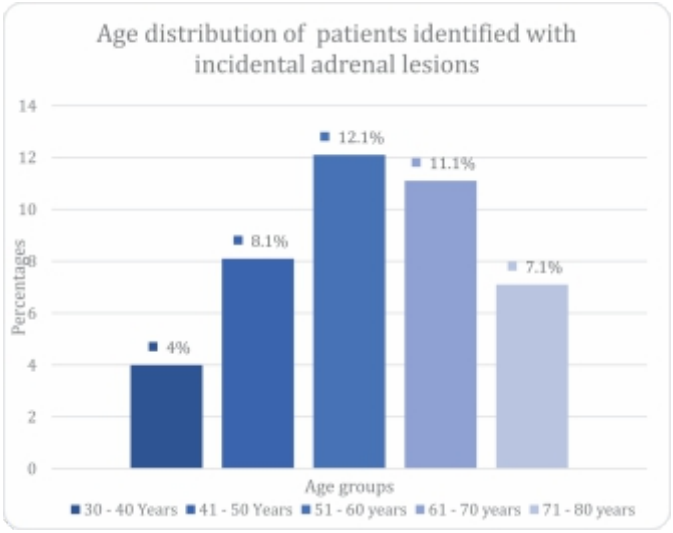

Figure 2: Age distribution of patients identified with incidental adrenal lesion

Radiological characteristics of adrenal incidentalomas

85.7% of AIs were detected on abdominal scan review, whereas 14.3% of cases were detected in the review of thoracic CT scan (Table 1). Majority of the patients (92.9%) exhibited unilateral lesions, with a mean size of 1.78 cm and an average density of -3.8 HU. 85.7% (95% CI: 71.5%–94.6%) of patients identified with AI were referred to the endocrine service for additional investigation. Of the six patients with missing data (14.3%), two (4.7%) lost their lives as a result of COVID-19, one (2.3%) refused medical advice, and three (7.1%) sought cancer care at other facilities (Figure 1). Four patients (9.5%; 95% CI: 3.1%–22.6%) were diagnosed with potential adrenal metastases, with the main malignancies being bronchogenic carcinoma, non-Hodgkin lymphoma, colonic carcinoma, and multiple myeloma (Table 1).

The proportion of lipid-rich AI was 52.4%, followed by iso-dense lesions at 14.3%, while all other imaging characteristics were below 10% (Table 2).

Table 1: Gender-wise distribution of demographic and clinical characteristics of the patients

	Males N=26 (61.9%)	**Females N=16 (38%)**	**Total N=42 (4.05%) 95% CI: 2.96–5.43**
Age (years)	58.69 ± 13.2 (31-82)*	57.06 ± 13.03 (31-83)*	58.07 ± 12.9 (31-83)*
Size (cm)	1.64 ± 0.64 (1-4)*	1.99 ± 0.603 (1-4)*	1.78 ± 0.64 (1-4)*
Density (HU)	-2.34± 33.2 (-97-44.29)*	-6.25 ± 26.8 (-94-30)*	-3.8± 30.6 (-97-44.2)*
Side of mass			
Unilateral	23 (88.5%)	16 (100%)	39 (92.9%)
Bilateral	3 (11.5%)	0 (0)	3 (7.1%)
Regional detection			
Chest imaging	4 (15.4%)	2 (12.5%)	6 (14.3%)
Abdominal/Pelvic	22 (84.6%)	14 (87.5%)	36 (85.7%)
Malignant /metastatic	3 (11.5%)	1 (6.3%)	4 (9.5%)
Referral to endocrinologists	20 (76.9%)	16 (100%)	36 (85.7%; 95% CI: 71.5-94.6)

**mean± SD (min-max)*

Table 2: Imaging characteristic of AI on CT scan

Imaging characteristic of AI	N=42
Calcified	2 (4.8%)
Lipid rich	22 (52.4%)
Lipid poor	2 (4.8%)
Myelolipoma	3 (7.1%)
Cyst	1 (2.4%)
Metastatic	2 (4.8%)
Iso-dense	6 (14.3%)
Hyperplasia	4 (9.5%)

AI – adrenal incidentalomas; CT – computed tomography

Hormonal evaluation and functional classification

ODST, 24-hour UFC for mild ACS, A:R ratio for aldosteronism, metanephrine for pheochromocytoma, and serum androgens were done to evaluate the functional activity of AI. The results (as shown in Table 3) showed that majority of patients had non-functional AI (57.1%; 95% CI: 41.7% –71.4%), 9.5% with possible aldosteronism (95% CI: 3.1%–22.6%), 16.7% (95% CI: 7.9%–31.9%) with functional mild ACS, 2.4% (95% CI: 0.1%–14.2%) with pheochromocytoma. Hormonal evaluation was not done for 14.3% as seen in Figure 3.

Cardiometabolic risk factors among patients with adrenal incidentaloma

Among AI individuals, 31 (73.8%; 95% CI: 58.0%–85.7%) had type-2 DM or pre-DM, hypertension was present in a total of 27 (64.3%; 95% CI: 48.7%–77.7%) patients, dyslipidemia was observed as high LDL-C in 28 (66.7%; 95% CI: 51.1%–79.6%) and high triglycerides (TG) in 7(16.7%; 95% CI: 7.9%–31.9%) patients. Weight categorization according to BMI showed that 3 (7.1%) were normal while 39 (92.9%; 95% CI: 80.9%–98.5%) were overweight and obese (Table 4).

Association of cardiometabolic risk factors with gender and hormonal subtype

A noticeable finding was seen in gender-based assessment of cardio-metabolic risk factors in AIs as a statistically significant association ($p < 0.05$) was observed between male AIs and cardiometabolic risk factors like DM/pre-DM ($p = 0.000$*), hypertension ($p = 0.000$*) and dyslipidemia (LDL-C $p = 0.001$*TG $p < 0.001$*) (Table 4). As can be seen in Table 5 pheochromocytoma and aldosteronism groups exhibited the highest burden of cardiometabolic risk factors, while non-functional AI cases had relatively lower frequencies across most parameters, however no statistically significant

association was observed between various sub categories and cardiometabolic risk factors. Frequency distribution of various cardio-metabolic risk factors in association with type of AI (on basis of hormonal evaluation) is presented in Figure 4.

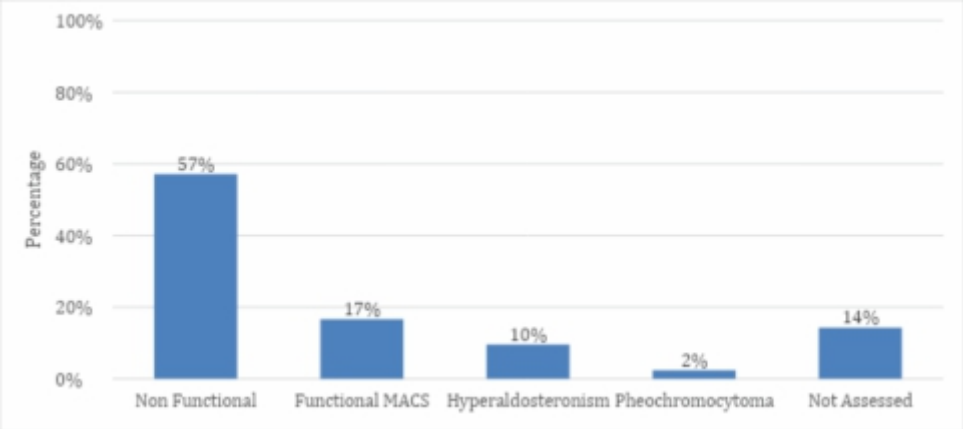

Figure 3: Functional status of AI patients based on hormonal evaluation. Functional MACS: Functional mild autonomous cortisol secretion

AI – adrenal incidentalomas; MACS – mild autonomous cortisol secretion

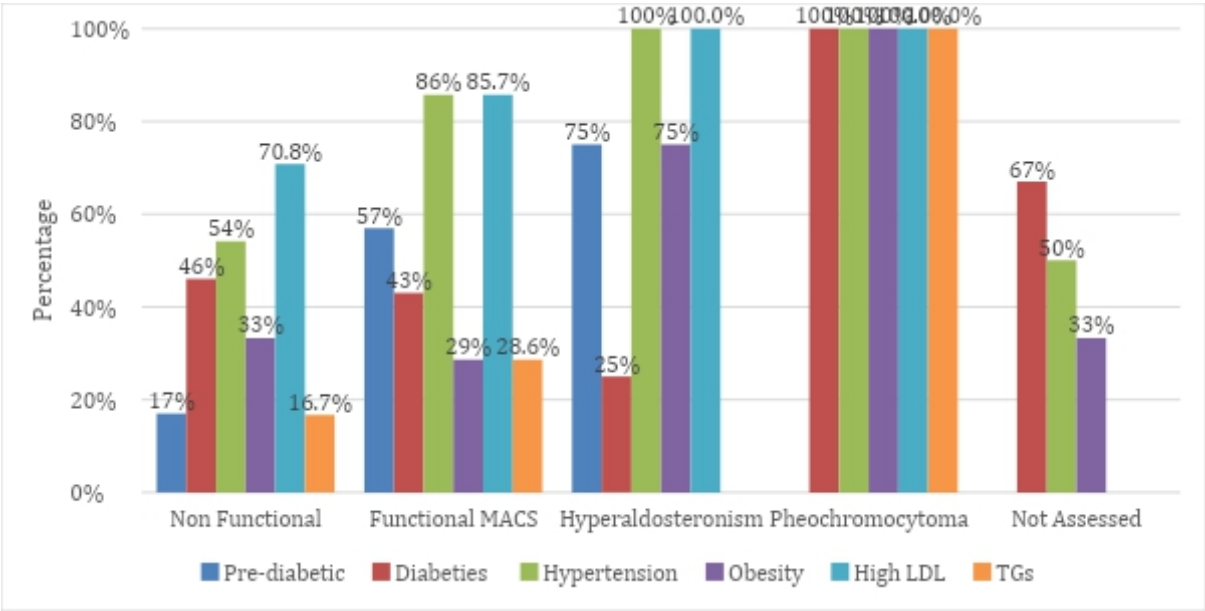

Figure 4: Graphical representation of association between cardio-metabolic risk factors along with the presence of type of adrenal lesion

AI – adrenal incidentalomas; MACS – mild autonomous cortisol secretion

Table 3: Gender wise distribution of hormonal evaluation results for patients with AI

	Males N=26 n (%)	Females N=16 n (%)	Total N=42 (n %; 95%CI)
A:R			
Normal	18 (69.2%)	14 (87.5%)	32 (76.2%; 61.5-86.5)
High	2 (7.7%)	2 (12.5%)	4 (9.5%; 3.8-22.1)
Not done	6 (23.1%)	0 (0)	6 (14.3%; 6.7-27.8)
24-hour urinary cortisol			
Positive	1 (3.8%)	1 (6.3%)	2 (4.8%; 1.3-15.8)
Negative	4 (15.4%)	4 (25%)	8 (19%; 10.0-33.3)
Not Done*	21 (80.8%)	11 (68.8%)	32 (76.2%; 61.5-86.5)
DST			
Positive	3 (11.5%)	3 (18.8%)	6 (14.3%; 6.7-27.8)
Negative	16 (61.5%)	13 (81.3%)	29 (69%; 54.0-80.9)
Not Done	7 (26.9%)	0 (0)	7 (16.7%; 8.3-30.6)
Metanephrine			
Positive	1 (3.8%)	0 (0)	1 (2.4%; 0.4–12.3)
Negative	19 (73.1%)	16 (100%)	35 (83.3%; 69.4–91.7)
Not Done	6 (23.1%)	0 (0)	6 (14.3%; 6.7–27.8)
Androgens			
Negative	20 (76.9%)	15 (93.8%)	35 (83.3%; 69.4–91.7)
Not Done	6 (23.1%)	1 (6.3%)	7 (16.7%; 8.3–30.6)

**DST was preferred to assess cortisol excess*

AI – adrenal incidentalomas; A:R aldosterone renin ratio;DST dexamethasone suppression test

Table 4: Association of cardio-metabolic risk factors with gender in AI patients

Cardiometabolic Risk Factors	Males N=26 n (%)	Females N=16 n (%)	Total N=42, n (%; 95% CI)	*p*
Diabetes/pre-DM	20 (76.9%)	11 (68.8%)	31 (73.8%; 58.0–85.7)	<0.001*
Hypertensive				
Positive	19 (73.1%)	8 (50%)	27 (64.3%; 48.7–77.7)	<0.001*
Negative	6 (23.1%)	8 (50%)	14 (33.3%; 20.8–49.0)	
Unknown	1 (3.8%)	0 (0)	1 (2.4%; 0.1–14.2)	

Continued...

LDL-C				
Normal	6 (23.1%)	4 (25%)	10 (23.8%; 12.9–39.7)	0.001*
Increased	16 (61.5%)	12 (75%)	28 (66.7%; 51.1–79.6)	
Unknown	4 (15.3%)	0 (0)	4 (9.5%; 3.1–22.6)	
TG				
Normal	19 (73.1%)	12 (38.7%)	31 (73.8%; 58.0–85.7)	<0.001*
Increased	3 (11.5%)	4 (57.1%)	7 (16.7%; 7.9–31.9)	
Unknown	4 (15.3%)	0 (0)	4 (9.5%; 3.1–22.6)	
Weight				
Normal	3 (7.1%)	0 (0)	3 (7.1%; 2.0–19.6)	0.083
Overweight / Obese	23 (88.4%)	16 (100%)	39 (92.8%; 80.4–98.0)	

**Fisher's exact test/chi-square test p<0.05*

AI – adrenal incidentalomas; DM – diabetes mellitus; LDL-C: low density lipoprotein –cholesterol; TG: triglycerides

Table 5: Cardio-metabolic risk factor distribution in various adrenal incidental lesions based on hormonal assessment

	Functional MACS N=7 n (%)	**Nonfunctional N=24 n (%)**	**Aldosteronism N=4 n (%)**	**Pheochromocytoma N=1 n (%)**	***p***
Diabetes / pre-DM	7 (100%)	15 (62.5%)	4 (100%)	1 (100%)	0.199
Non-diabetic	0 (0)	9 (37.5%)	0 (0)	0 (0)	0.206
Hypertensive					
Positive	6 (85.7%)	13 (54.2%)	4 (100%)	1 (100%)	0.174
Negative	1 (14.3%)	11 (45.8%)	0 (0)	0 (0)	
LDL-C					
Normal	1 (14.2%)	7 (29.1%)	0 (0)	0 (0)	0.122
Increased	6 (85.7%)	17 (70.8%)	4 (100%)	1 (100%)	
TG					
Normal	5 (71.4%)	20 (83.3%)	4 (100%)	0 (0)	0.240
Increased	2 (28.6%)	4 (16.6%)	0 (0)	1 (100%)	
Weight					
Normal	0 (0)	1 (4.1)	0 (0)	0 (0)	0.219
Overweight	5 (71.4%)	15 (62.5%)	1 (25%)	0 (0)	
Obese	2 (28.6%)	8 (33.3%)	3 (75%)	1 (100%)	

**Fisher's Exact Test p<0.05*

MACS – mild autonomous cortisol secretion; DM – diabetes mellitus; LDL-C: low density lipoprotein –cholesterol; TG: triglycerides

Discussion

Research shows that the prevalence of AI varies significantly based on clinical context, patient characteristics (like known adrenal pathology/ underlying cancer), the techniques employed, and the radiologist's expertise. Frequency varies between 1.05%-8.7% which was observed in our study as well [18]. In our study, 85.7% of patients were referred to the endocrine service for further investigations, reflecting on good intra departmental referral system in contrast with a UK study where 90% of cases were not referred for follow-up [19]. It might be due to inter-observer variability, the radiologist's experience, the busy radiology service, and a greater emphasis on results pertaining to the original indication for which imaging was performed. In our observation, six patients were not referred for further follow-up to endocrinology service. Lack of immediate clinical effects, the low likelihood of malignancy (0.72 million/year) [5], the subclinical/subtle hormone hypersecretion without clinical manifestations, and the unfamiliarity of the physician who ordered the imaging might be reasons for not referring to the concerned specialty in time. While the majority of AIs are benign and hormone-inactive, 20% are hormonally active or malignant, necessitating immediate attention to protect the patient's health and safety [5,20]. Age distribution trend in Saudi population in our study is consistent with other studies with increased prevalence with aging [5,18]. Males were more likely to have AI (61.9%), which is consistent with the findings of a prospective cohort study [21]. This contrasts with the findings of another retrospective study conducted at Armed Forces Hospital Southern Region in Saudi Arabia, which indicated a nearly equal distribution between genders [22]. Male to female ratio in current study was 1.62 similar to COAR study carried out in Korea where male to female ratio was 1.35 [23].

AI, described as the "disease of modern technology," has a higher prevalence due to enhanced imaging techniques [4]. The research indicated a higher prevalence of AIs in CT abdomen (about 85%), and 92.9% of lesions to be unilateral which aligns with the previous research [24]. The metastatic adrenal lesions (9.5% of AI) in our study were related to multiple myeloma, non-Hodgkin lymphoma, colonic carcinoma and bronchogenic carcinoma and it was consistent with literature [25,26]. Primary adrenal lymphoma is very rare entity (< 1%), however secondary adrenal involvement can occur with advanced stage of lymphoma as seen in our patient [26].

Lipid-rich AIs were found in 52.4% of cases, followed by iso-dense lesions at 14.3%, while all other types, like calcified, lipid-poor, myelolipoma, and metastatic lesions, were less than 10%. Furthermore, most of AIs in our sample were small, with only 3 (7%) exceeding 3 cm and 1 (2.3%) measuring 4 cm. The European Society of Endocrinology advises against additional radiological investigations for lesions that are homogeneous and measure less than 4 cm on non-contrast CT scans [12].

Higher cardiovascular morbidity and death are linked to AIs with elevated cortisol secretion [27]. Hormonal evaluation in current study showed that 57.1% incidentalomas were non-functional, 16.7% possible MACS (functional MACS), 9.5% possible aldosteronism, 2.4% possible pheochromocytoma and 14.3% functional status unknown (due to death/left against medical advice/following in oncology services). A retrospective analysis of AI

cases in a Hong Kong tertiary institution revealed findings analogous to our study, with 19.4% attributable to excess cortisol, 8.6% to excess aldosterone, and 8.6% to excess catecholamines [28]. As in other research, the most common hormonal abnormality observed in our research was cortisol hypersecretion [11]. ACS is divided into MACS and definitive ACS on basis of serum cortisol after ODST. MACS is defined as > 1.8µg/dl cortisol after ODST, which requires further confirmatory testing as single marginally elevated result is not diagnostic. On the other hand, definitive ACS, cut off limit of ≥ 5 µg/dl is used by some authors [11]. In current study due to our small study group, we limited our definition of ACS to MACS (functional MACS) by using cut off limit of > 1.8µg/dl after ODST, to separate it from normal but couldn't confirm definitive ACS. In our study, cardio-metabolic risk factors such as T2DM, pre-DM, hypertension, high LDL-C and high TG, or obesity were observed. Previous research also supports these findings [21,27]. These findings in our study are independent of hormonal activity assessment. The adrenal-adipose axis can help explain the association between these cardiometabolic risk factors and AI, however, due to retrospective nature of research and hence lack of mechanistic markers, it could not be assessed in our research. In our research, male AI individuals were found to have significant association (p value < 0.05) with cardio-metabolic risks as compared to females in contrast to other published research [29].

Limitations

Our study has various limitations such as, the retrospective study design due to which some data such as hormonal evaluation and cardiometabolic risk factors were not available, and CT techniques could not be standardized. Due to single center study and small sample size, statistical associations could not be established particularly for various subgroups.

Conclusion

Most of the adrenal incidentalomas in our research were small, unilateral, benign, and had cardiovascular comorbidities. The findings lay stress on more vigilant radiological reporting to ensure timely referral of identified cases of AI for further follow ups to concerned specialties.

Acknowledgements

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References

1. Ceccato F, Barbot M, Scaroni C, Boscaro M. Frequently asked questions and answers (if any) in patients with adrenal incidentaloma. *J Endocrinol Investig* 2021; 44(12):2749-2763.
2. Potekar RM, Goyal S. Adrenal myelolipoma associated with cholelithiasis - A rare case report. *J Krishna Inst Med Sci Univ* 2017; 6(1):132-134.
3. Dwivedi A, Choudhary S, Trehan V, Yadav N, Leela Kanth K. Large pseudocyst of the adrenal gland: A radiological pathological correlation. *J Krishna Inst Med Sci Univ* 2017; 6(1):112-116.
4. Chatzellis E, Kaltsas G. Medicine (Spain). MDText.com, Inc.; Vol. 13, 2024. Adrenal Incidentaloma. Available from: https://www.ncbi.nlm.nih.gov/books/NBK279021/
5. Minnaar EM, Human KE, Henneman D, Nio CY, Bisschop PH, Nieveen van Dijkum EJM. An adrenal incidentaloma: How often is it detected and what are the consequences? *ISRN Radiol* 2013; 2013:1-4.
6. Jackson BS. Adrenal incidentaloma controversial size recommendations. *Urol Res Pract* 2023; 49(2): 96-99.

7. McDermott S, O'Connor OJ, Cronin CG, Blake MA. Radiological evaluation of adrenal incidentalomas: current methods and future prospects. *Best Pract Res Clin Endocrinol Metab* 2012; 26(1):21-33.
8. Muangnoo N, Manosroi W, Leelathanapipat N, Meejun T, Chowchaiyaporn P, Teetipsatit P. Predictive factors of functioning adrenal incidentaloma: A 15-year retrospective study. *Medicina (Kaunas)* 2022; 58(5):597.
9. Aresta C, Favero V, Morelli V, Giovanelli L, Parazzoli C, Falchetti A *et al*. Cardiovascular complications of mild autonomous cortisol secretion. *Best Pract Res Clin Endocrinol Metab* 2021; 35(2):101494.
10. Elhassan YS, Alahdab F, Prete A, Delivanis DA, Khanna A, Prokop L, *et al*. Natural history of adrenal incidentalomas with and without mild autonomous cortisol excess: A systematic review and meta-analysis. *Ann Intern Med* 2019; 171(2):107-116.
11. Lee JM, Kim MK, Ko SH, Koh JM, Kim BY, Kim SW, *et al*. Clinical Guidelines for the Management of Adrenal Incidentaloma. *Endocrinol Metab (Seoul)* 2017; 32(2): 200-218.
12. Fassnacht M, Tsagarakis S, Terzolo M, Tabarin A, Sahdev A, Newell-Price J *et al*. European Society of Endocrinology clinical practice guidelines on the management of adrenal incidentalomas, in collaboration with the European Network for the Study of Adrenal Tumors. *Eur J Endocrinol* 2023; 189(1):G1-G42.
13. Higgs JA, Quinn AP, Seely KD, Richards Z, Mortensen SP, Crandall CS, *et al*. Pathophysiological link between insulin resistance and adrenal incidentalomas. *Int J Mol Sci* 2022; 23(8):4340.
14. Cao H. Adipocytokines in obesity and metabolic disease. *J Endocrinol* 2014; 220(2):T47-59.
15. Kargi AY, Iacobellis G. Adipose tissue and adrenal glands: novel pathophysiological mechanisms and clinical applications. *Int J Endocrinol* 2014; 2014:614074.
16. Kiszczak-Bochyńska E, Oszywa A, Kurowska M, Malicka J, Dudzińska M, Tarach JS. Features of metabolic syndrome in patients with adrenal incidentalomas. *Fam Med Prim Care Rev* 2014; 16(3):242–4.
17. Szychlińska M, Baranowska-Jurkun A, Matuszewski W, Wołos-Kłosowicz K, Bandurska-Stankiewicz E. Markers of subclinical cardiovascular disease in patients with adrenal incidentaloma. *Medicina (Kaunas)* 2020; 56(2):69.
18. Sherlock M, Scarsbrook A, Abbas A, Fraser S, Limumpornpetch P, Dineen R, *et al*. Adrenal Incidentaloma. *Endocr Rev* 2020; 41(6):775–820.
19. Hanna FWF, Hancock S, George C, Clark A, Sim J, Issa BG, *et al*. Adrenal incidentaloma: Prevalence and referral patterns from routine practice in a large UK University teaching hospital. *J Endocr Soc* 2021; 6(1):bvab180.
20. Hanna F, Issa B, Lea S, George C, Golash A, Firn M, *et al*. SAT-373 Adrenal Incidentaloma Unidentified Case Load: Are We Dealing Only with the Tip of the Iceberg? *J Endocr Soc* 2019; 3(Suppl 1): SAT-373.
21. Reimondo G, Castellano E, Grosso M, Priotto R, Puglisi S, Pia A, *et al*. Adrenal incidentalomas are tied to increased risk of diabetes: Findings from a prospective study. *J Clin Endocrinol Metab* 2020; 105(4): E973-81.
22. Dosogi Elzain WA, Alshalaan AM, Al Qahtani MMM, Al Qahtani HAA, Assiri DH, Alshehri HH, *et al*. Adrenal Incidentaloma Prevalence and Clinical Management - A Retrospective Study. *Am J Med Sci Innov* 2024; 3(1):8-17.
23. Ahn SH, Kim JH, Baek SH, Kim H, Cho YY, Suh S, *et al*. Characteristics of adrenal incidentalomas in a large, prospective computed tomography-based multicenter study: The COAR study in Korea. *Yonsei Med J* 2018; 59(4):501-510.
24. Gendy R, Rashid P. Incidental adrenal masses - A primary care approach. *Aust Fam Physician* 2017; 46(6):385-390.
25. van den Broek J, Geenen R, Heijnen L, Kobus C, Schreurs H. Adrenal incidentalomas during diagnostic work-up of colorectal cancer patients: What is the risk of metastases? *Ann Surg Oncol* 2018; 25(7):1986-1991.
26. Rezkallah EMN, Hanna RS, Elsaify WM. Adrenal lymphoma: Case reports and mini-review. *Int J Endocrinol Metab* 2022; 20(4):e128386.

27. Remde H, Kranz S, Morell SM, Altieri B, Kroiss M, Detomas M, *et al*. Clinical course of patients with adrenal incidentalomas and cortisol autonomy: a German retrospective single center cohort study. *Front Endocrinol (Lausanne)* 2023; 14:1123132.
28. Ng VW, Ma RC, So WY, Choi KC, Kong AP, Cockram CS, *et al*. Evaluation of functional and malignant adrenal incidentalomas. *Arch Intern Med* 2010; 170(22):2017-20.
29. Puglisi S, Barač Nekić A, Morelli V, Alessi Y, Fosci M, Pani A, *et al*. Are comorbidities of patients with adrenal incidentaloma tied to sex? *Front Endocrinol (Lausanne)* 2024; 15:1385808

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