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Qualification en RADIODIAGNOSTIC ET IMAGERIE MEDICALE

Découvertes fortuites sur les scanners d'urgences : facteurs prédictifs et impact médico-économique

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Liste des abréviations

CT	Computed Tomography
DRG	Diagnosis-Related Group
ED	Emergency Department
GIST	Gastrointestinal Stromal Tumor
IF	Incidental Finding
IFCS	Incidental Finding of high Clinical Significance
MDCT	Multidetector Computed Tomography
MRI	Magnetic Resonance Imaging
SD	Standard Deviation

Plan

Incidental findings on emergency CT scans: predictive factors and medico-economic impact

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ABSTRACT

Purpose: The main objective was to evaluate types and predictive factors of incidental findings (IFs) on multidetector computed tomographies (MDCTs) performed for an emergency department (ED). The secondary aim was to analyze additional investigations, their benefits, side effects, costs and the final diagnoses.

Method: One thousand consecutive patients over 18 years old who underwent an MDCT in the ED of our institution from January 2011 to November 2011 were retrospectively included, accounting for 300 head MDCTs and 700 other MDCTs. The following criteria were collected in patient electronic medical records: IFs (divided into low and high clinical significance), body areas covered, availability of a prior imaging, radiologist's experience and subspecialty, additional investigations, their outcomes and costs.

Results: Among the 1000 included patients, 232 had at least one IF and 122 had at least one IF of high clinical significance (IFCS). There were 340 IFs and 150 IFCSs. A significant association with the presence of at least one IF was noted for older patients, less-experienced radiologists, no subspecialty of the radiologist, the abdominopelvic area, and the absence of prior imaging. Eighteen IFs generated additional investigations in our institution, including five invasive samplings and three surgical operations, with two diagnoses of malignancy (a gastrointestinal stromal tumor and a Bosniak IV cystic renal lesion). One benign iatrogenic complication occurred. Total cost of these investigations was €41,247 (with an average of €2,292 per IF investigated).

Conclusion: IFs on emergency MDCTs were frequent, rarely severe, rarely iatrogenic and relatively expensive.

INTRODUCTION

General background

Multidetector computed tomographies (MDCTs) ordered by emergency departments (ED) are supposed to answer a well-targeted question [1]. However, MDCTs often lead to incidental findings (IFs), defined as "results that are outside the original purpose for which the test was conducted" [2,3]. In the literature, each emergency MDCT reveals an average of 0.6 to 2.2 IFs [4,5], and 19 to 40% of these present at least one IF of high clinical significance (IFCS) [5,6].

Specific background

IFs often lead to additional investigations, providing an opportunity to diagnose relevant diseases, such as cancers, in their preclinical phase [7]. However, these investigations are sometimes invasive and can cause side effects as in the study of Morgan AE et al. in 2015 reporting two deaths from surgical procedures related to extra-urinary IFs on 143 computed tomographies (CTs) performed for hematuria [8]. The risk-benefit ratio of IFs has received little academic attention in the literature [9]. The main issue is the lead time bias, i.e. a distortion of our perception of the survival time created by a disease detection in its preclinical phase [10]. In addition, it is recognized that IFs may cause anxiety in patients [11,12]. Moreover, additional investigations linked to IFs are costly for society [2,13] while the vast majority of IFs are not malignant, only 3% in Kelly's study [7]. In the literature, many papers described the rate of IFs in special clinical situations [7,8,14]. Many papers also suggested guidelines to manage the follow-up of IFs [15,16]. But to our knowledge, no paper examined the IFs problem in the emergency room imaging in a global way, in particular concerning the predictive factors of the presence of IFs in the reports of radiologists and

emergency physicians. Likewise, the overall prognosis of patients and the cost to society has not been studied in a global manner for IFs performed on emergency CT scans.

Issue

The radiologist has a duty to analyze the whole data contained in the pictures, even those not related to the symptomatology [9,17]. Obviously, if a radiologist notes an abnormality, he/she cannot ignore it and must communicate it because he/she cannot judge alone if this finding is relevant or not regarding the patient's history. However, is it appropriate to actively search for any small abnormality unrelated to the symptomatology that could be present on the field of acquisition of an MDCT ordered by an emergency physician? Taken to the extreme, could it be deleterious to the patient or society?

Purpose

The main aim of this study was to evaluate types, prevalence and predictive factors of IFs on MDCTs performed for an ED.

Secondary aims were:

- to study the transmission of the IFs from the radiologist to the ED and predictive factors of their report in the emergency discharge paperwork;
- to inventory additional tests and procedures performed for each IF, their benefits, side effects, costs and the final diagnoses.

METHOD

Patients

This study was approved by our local institutional ethics review board.

One thousand individual consecutive patients over 18 years old who underwent a CT scan in the ED of our tertiary referral university-affiliated hospital from January 2011 to November 2011 were retrospectively included.

Although brain CT scans represented two thirds of all CT scans in the ED of our institution, we limited inclusion to 300 consecutive patients who underwent a single brain CT scan, to avoid an overrepresentation of brain CT scans. The other 700 patients underwent a CT scan covering other parts of body that could include the brain (named "non-brain CT scans").

CT scans

All CT scans were performed in our institution on a 64-slice MDCT (Optima CT660, GE Healthcare, date of commissioning: September 2010). MDCT parameters were: 512x512 pixel matrix, 64x0.625 mm collimation. Slice thickness and reconstruction interval were 1.25 mm and 0.90 mm respectively for abdominopelvic MDCTs, 1.25 mm and 0.63 mm for head and neck MDCTs, and 0.63 mm and 0.63 mm for lung, spine and limb MDCTs. Intravenous contrast agents were Omnipaque 350 mg/ml (GE Healthcare), Visipaque 320 mg/ml (GE Healthcare) or Xenetix 350 mg/ml (Guerbet).

Recorded data

All patient electronic medical records were retrospectively read by a single radiology resident who collected the following criteria:

- age and sex of patients;
- IFs in the MDCT report;

- body areas covered by the CT scan (head, neck, chest, abdominopelvic cavity, spine, limbs);
- MDCT time of day;
- availability of a prior CT scan or Magnetic Resonance Imaging (MRI) covering the same area during the previous 10 years on our Radiological Information System or on our Picture Archiving and Communication System;
- radiologist's experience, considering as junior if they were resident or graduated less than two years ago, and senior for other cases;
- radiologist's subspecialty (head and neck, chest, digestive, urology, musculoskeletal, vascular, pediatric, general);
- clinical indication of the MDCT;
- presence of an abnormality in the MDCT report supposedly related to the patient's symptomatology;
- hospitalization or direct home discharge after emergency admission;
- report of the IF and advice to carry out additional investigations in the emergency discharge paperwork;
- in the subgroup of patients followed in our institution: additional examinations and treatments related to the IF until 2019, their costs, the final recorded diagnoses and overall 5-year mortality.

Incidental findings

IFs were defined as "findings unrelated to the chief complaint and not pertinent to the immediate patient care in the ED" [18]. All the IFs were collected and grouped by similarity. They were divided into low and high clinical significance: IFs of high clinical significance were defined as needing additional tests or care according to guidelines from scientific societies [13].

In *supplementary material I*, items not recorded as IFs (because of very high frequency and very low clinical significance) are listed [6].

Cost of additional care

For cost evaluation, the perspective chosen is the French national health insurance system. Indeed, additional examinations and treatments will principally impact the French national health insurance system. The costs are expressed in euros (€). We chose to use 2019 rates to better represent the costs of medical investigations.

In France, a price is allocated to each medical act performed for outpatients (for example, €180 for adrenal scintigraphy [19]) and refunded at a rate of 70% for medical fees or professional component of radiology procedures, 100% for technical component of radiology procedures and 60% for biological tests.

For hospitalized patients, the French national healthcare system provides a global financial envelope for the whole patient hospital stay depending on the reason for hospitalization and its length: rate of diagnosis-related group (DRG) (for example, €4,935 for stay for adrenalectomy lasting less than 7 days [20]). The rate of DRG includes in particular imaging, biology, surgery and drugs.

Statistical analysis

Univariate analyses were performed using Fisher's exact test and chi-squared test for categorical variables, and Mann–Whitney U test for quantitative variables. Multivariate analyses were performed using multinomial logistic regression. A P-value lower than 0.05 was considered significant. Sample size was derived with an Arcsin approximation (878 patients to compare two proportions of 0.25 and 0.35 with two-tailed tests and alpha and beta risks of 0.05 and 0.1 respectively). Statistical analyses were achieved with the online biostatistics software of our National Institute for Health and Medical Research (INSERM), and with Statistical Package for the Social Sciences (SPSS) version 20.0.0 (IBM corporation).

RESULTS

1. Description of the population and the incidental findings

1.1. Population

Among the 300 patients who underwent a brain MDCT, 52% (157/300) were women, the mean age was 54.5 years old (SD: 24.4), 11% (33/300) had at least one IF, and 1% (4/300) had at least one IFCS. Among the 700 patients who underwent a non-brain CT scan, 46% (320/700) were women, the mean age was 50.9 years old (SD: 21.9), 28% (199/700) had at least one IF, and 17% (118/700) had at least one IFCS.

Thirteen percent of patients (127/1000) were hospitalized following the ED admission, 3% (34/1000) died in the ED or in the following hospitalization, 45% (447/1000) had their CT scan between 8:00 am and 6:00 pm. The main clinical indications were head trauma (10%, 100/1000), stroke (11%, 107/1000), full-body CT for trauma (15%, 150/1000), suspected pulmonary embolism (17%, 172/1000), renal colic (4%, 43/1000), bowel obstruction (3%, 30/1000). A prior sectional imaging during the past 10 years was available for 18% of patients (182/1000). The MDCT was read by a junior radiologist for 22% of patients (218/1000), and by a general radiologist for 9% of patients (90/1000). A diagnosis related to the chief complaint was made for 33% of patients (326/1000).

1.2. Incidental findings

In the 300 brain CT scans, there were 47 IFs, of which 6 were IFCSs. In the 700 non-brain CT scans, we reported 293 IFs, of which 144 were IFCSs. Twenty-six percent of IFs (87/340) and 37% of IFCSs (55/150) were reported in the emergency discharge paperwork, with a recommendation to carry out additional investigations for 8% of IFs (27/340) and 15% of IFCSs (22/150). Eighteen IFs generated additional investigations in our institution, *figure 1*. The full list of IFs is available in *supplementary material II*.

Among the 135 patients who underwent a full-body CT scan for trauma, 27% (36/135) had at least one IF, and 13% (17/135) at least one IFCS (mean age: 36.4 years old, SD: 17.2). Regarding patients with suspected pulmonary embolism, 12% (21/171) had at least one IF and 9% (15/171) at least one IFCS (mean age: 59.5 years old, SD: 20.7). In abdominopelvic emergency MDCTs, 35% (148/425) of patients had at least one IF and 20% (83/425) at least one IFCS (mean age: 46.7 years old, SD: 21.3).

The most common IFCS was the hepatic nodule, which accounted for 6% of abdominopelvic IFs (14/221) in six women, with a mean age of 49.6 years old (SD: 17.4), six reports in the emergency discharge paperwork, and two follow-ups. The main others IFCS were lung nodules, steatosis, adrenal mass, biliary tract dilatation, ovarian cysts, urinary tract dilatation, and thyroid nodules: *figure 2*.

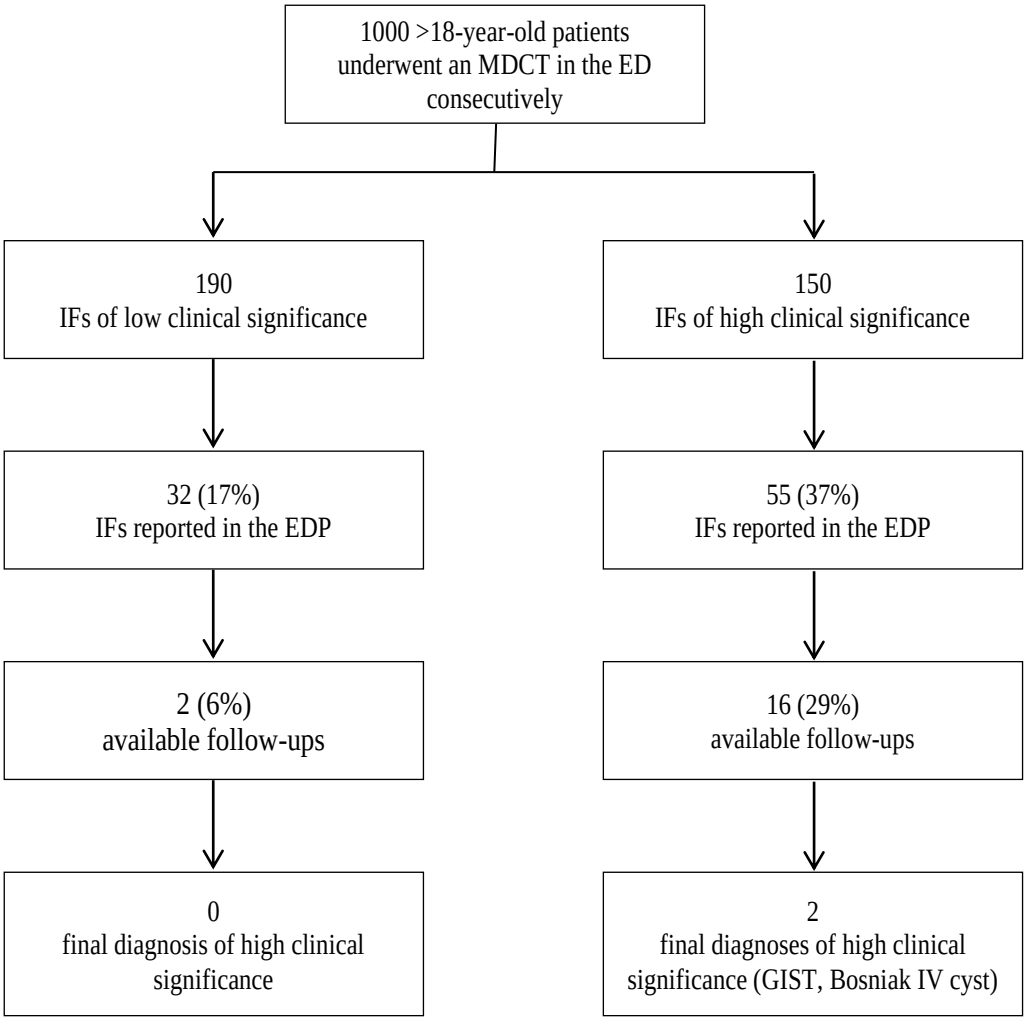

Figure 1: Flow-chart.
ED: emergency department. EDP: emergency discharge paperwork. GIST: gastrointestinal stromal tumor. IF: incidental finding. MDCT: multidetector computed tomography.

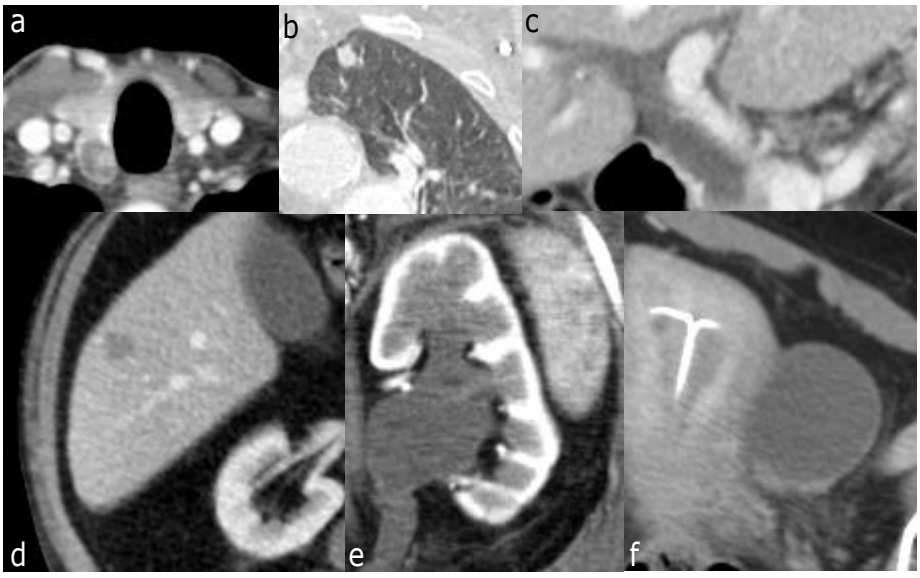

Figure 2: Examples of common significant incidental findings.
a) Thyroid nodule. b) Lung nodule. c) Biliary tract dilatation. d) Liver nodule. e) Urinary tract dilatation. f) Ovarian cyst.

2. Predictive factors of incidental findings

2.1. Factors associated with the presence of an incidental finding

Incidental findings of low and high clinical significance

In multivariate analysis, a significant statistical association with the presence of at least one IF was noted for: older patients (55.9 years old, SD:21.2 versus 50.7 years old, SD: 24.6; OR = 1.01; 95% CI = [1.007; 1.02]; p<0.001), less experienced radiologists (33% for junior versus 21% for senior; OR = 2.2; 95% CI = [1.5; 3.0]; p<0.001), no subspecialty of the radiologist (37% for general radiologist versus 22% for specialized radiologist; OR = 2.6; 95% CI = [1.6; 4.2]; p<0.001), abdominopelvic area (35% versus 9% for other regions; OR = 7.1; 95% CI = [5.1; 9.9]; p<0.001), and the absence of prior sectional imaging (25% versus 16%; OR = 2.1 ; 95% CI = [1.4; 3.3]; p=0.001), *table I*.

We did not observe any significant association between the presence of an IF and five-year mortality, the time of day or the presence of an abnormality on the MDCT to explain the chief symptom.

Incidental findings of high clinical significance

In multivariate analysis, a significant statistical association with the presence of at least one IFCS was noted for: older patients (56.2 years old, SD: 19.7 versus 51.3 years old, SD: 23.0; OR = 1.01; 95% CI = [1.002; 1.02]; p=0.01), less experienced radiologists (17% versus 11%; OR = 1.8; 95% CI = [1.2; 2.8]; p=0.006), no subspecialty of the radiologist (18% versus 12%; OR = 1.9; 95% CI = [1.1; 3.5]; p=0.03), abdominopelvic area (20% versus 4%; OR = 9.4; 95% CI = [6.0; 14.9]; p<0.001).

There was no significant association between the presence of an IFCS and five-year mortality, the time of day, the presence of prior sectional imaging or the presence of an abnormality on the MDCT to explain the chief symptom.

Table I: Factors associated with the presence of an incidental finding

I.a: univariate analysis

Factors	All (n=1000)	IF (n=232)	no IF (n=768)	p	IFCS (n=122)	no IFCS (n=878)	p
Mean age *years old (SD)*	51.9 (22.7)	55.9 (21.2)	50.7 (24.6)	**0.001**	56.2 (19.7)	51.3 (23.0)	**0.02**
Sex							
Female	477	103 (22%)	373 (78%)	0.3	57 (12%)	420 (88%)	0.8
Male	523	129 (25%)	395 (75%)		65 (12%)	458 (88%)	
Body area							
Abdomen-pelvis	425	148 (35%)	277 (65%)	**<0.001**	83 (20%)	342 (80%)	**<0.001**
Chest	390	43 (11%)	347 (89%)		31 (8%)	359 (92%)	
Spine-Limbs	91	8 (9%)	83 (91%)		2 (2%)	89 (98%)	
Head	443	44 (10%)	399 (90%)		6 (1%)	437 (99%)	
Neck	163	3 (2%)	160 (98%)		1 (1%)	162 (99%)	
MDCT time							
8 am - 6 pm	553	134 (24%)	419 (76%)	0.4	67 (12%)	486 (88%)	0.9
6 pm - 8 am	447	98 (22%)	349 (78%)		55 (12%)	392 (88%)	
Prior sectional imaging							
Yes	182	30 (16%)	152 (84%)	**<0.001**	18 (10%)	164 (80%)	**0.008**
No	818	202 (25%)	616 (75%)		104 (13%)	714 (77%)	
Radiologist							
Senior	782	161 (21%)	621 (79%)	**<0.001**	85 (11%)	697 (89%)	**0.01**
Junior	218	71 (33%)	147 (67%)		37 (17%)	181 (83%)	
General	90	33 (37%)	57 (63%)	**0.002**	16 (18%)	84 (82%)	0.2
Subspecialized	910	199 (22%)	711 (48%)		106 (12%)	804 (88%)	
MDCT							
positive for indication	326	78 (24%)	248 (76%)	0.7	47	279	0.1
negative for indication	674	154 (23%)	520 (77%)		75	599	
Hospitalization							
Yes	127	31 (24%)	96 (76%)	0.7	19 (15%)	108 (85%)	0.3
No	873	201 (23%)	672 (77%)		103 (85%)	770 (15%)	
5-year death (487 md)							
Yes	93	21 (23%)	72 (77%)	1	11 (12%)	82 (88%)	0.9
No	420	98 (23%)	322 (77%)		56 (13%)	364 (87%)	

I.b: multivariate analysis

Factors	At least one IF			At least one IFCS		
Age	OR = 1.01	95% CI = [1.007; 1.02]	**p<0.001**	OR = 1.01	95% CI = [1.002; 1.02]	**p=0.01**
Area						
AP	OR = 7.1	95% CI = [5.1; 9.9]	**p<0.001**	OR = 9.4	95% CI = [6.0; 14.9]	**p<0.001**
Chest	OR = 0.4	95% CI = [0.3; 0.6]	**p<0.001**	OR = 0.1	95% CI = [0.05;0.3]	**p<0.001**
Spine-limbs	OR = 0.4	95% CI = [0.2; 0.9]	**p=0.03**	OR = 0.1	95% CI = [0.02; 0.8]	**p=0.03**
Head	OR = 0.5	95% CI = [0.3; 0.7]	**p<0.001**	OR = 0.1	95% CI = [0.05; 0.3]	**p<0.001**
Neck	OR = 0.1	95% CI = [0.02; 0.3]	**p<0.001**	OR = 0.1	95% CI = [0.01; 0.6]	**p<0.001**
No prior sectional imaging	OR = 2.1	95% CI = [1.4; 3.3]	**p=0.001**	OR = 1.6	95% CI = [0.9; 2.7]	p=0.1
Radiologist						
Junior	OR = 2.2	95% CI = [1.5; 3.0]	**p<0.001**	OR = 1.8	95% CI = [1.2; 2.8]	**p=0.006**
General	OR = 2.6	95% CI = [1.6; 4.2]	**p<0.001**	OR = 1.9	95% CI = [1.1; 3.5]	**p=0.03**
MDCT negative	OR = 1.05	95% CI = [0.8; 1.5]	p=0.8	OR = 0.8	95% CI = [0.5; 1.2]	p=0.3

AP: abdomen-pelvis. IF: incidental finding. IFCS: incidental finding of high clinical significance. md: missing data. MDCT: multidetector computed tomography. OR: Odds ratio. SD: standard deviation. CI: confidence interval.

2.2. Association between incidental findings of a body area and subspecialization of the radiologist in this area

In multivariate analysis, digestive and uroradiologists described significantly more digestive and urologic IFs than the other radiologists (75% versus 60%; OR = 1.9; 95% CI = [1.1; 3.2]; p=0.01). The same phenomenon was noted for IFCSs (80% versus 60%; OR = 2.5; 95% CI = [1.1; 5.7]; p=0.02), *table II*. This association was not observed for other subspecialties, except for musculoskeletal radiologists concerning all IFs regardless of their clinical significance (10% versus 4%; OR = 3.3; 95% CI = [1.05; 8.6]; p=0.04).

Table II: Association between incidental findings of a body area and subspecialization of the radiologist in this area (multivariate analysis)

Radiologist's specialty	Presence of an IF in their specialty	Presence of an IFCS in their specialty
Head-neck	OR = 0.3 95% CI = [0.1; 1.0] p=0.051	not applicable (division by 0)
Chest	OR = 2.8 95% CI = [0.7; 11.6] p=0.1	OR = 4.7 95% CI = [0.6; 37.0] p=0.1
Digestive-Urology	OR = 1.9 95% CI = [1.1; 3.2] **p=0.01**	OR = 2.5 95% CI = [1.1; 5.7] **p=0.02**
Musculoskeletal	OR = 3.3 95% CI = [1.05; 8.6] **p=0.04**	OR = 1.2 95% CI = [0.2; 6.9] p=0.8

(potential confounding factors included in the analysis: age of patients, radiologists' experience)
IF: incidental finding. IFCS: incidental finding of high clinical significance. OR: Odds ratio. 95% CI: 95% confidence interval.

2.3. Factors associated with the incidental findings report in the emergency discharge paperwork

In multivariate analysis, a significant statistical association with the IF report in the emergency discharge paperwork was noted for high clinical significance of the IF (63% versus 36%; OR = 3.6; 95% CI = [2.1; 6.1]; p<0.001), and the absence of MDCT diagnosis to explain symptomatology (75% versus 25%; OR = 1.9; 95% CI = [1.03; 3.4]; p=0.04), *table III*.

Table III: Factors associated with the incidental finding report in the emergency discharge paperwork

Factors	Report (n=87)	No report (n=246)	p (uni-variate)	OR (multivariate)		
Mean age *years old (SD)*	60.2 (20.8)	56.1 (20.5)	0.1	OR = 1.01	95% CI = [1.0; 1.03]	p=0.051
Time						
8 am - 6 pm	52 (27%)	142 (73%)	0.8	OR = 1.3	95% CI = [0.8; 2.2]	p=0.3
6 pm - 8 am	35 (25%)	104 (75%)		*reference*		
Significance of IF						
high	55 (38%)	89 (62%)	**<0.001**	OR =3.6	95% CI = [2.1; 6.1]	**p<0.001**
low	32 (17%)	157 (83%)		*reference*		
MDCT						
negative for indication	65 (29%)	157 (71%)	0.07	OR = 1.9	95% CI = [1.03; 3.4]	**p=0.04**
positive for indication	22 (20%)	89 (80%)		*reference*		
Hospitalization						
No	81 (28%)	210 (72%)	0.06	OR = 2.4	95% CI = [0.9; 6.1]	p=0.07
Yes	6 (14%)	36 (86%)		*reference*		

7 pieces of emergency discharge paperwork missing.
MDCT: multidetector computed tomography. IF: incidental finding. OR: Odds ratio. SD: standard deviation. 95% CI: 95% confidence interval.

3. Additional investigations, costs and final diagnoses generated by incidental findings

Among the 122 patients presenting at least one IFCS, 11% (14/122) came back to our institution for additional investigations, including six invasive procedures. Five underwent transcutaneous biopsies or transdigestive biopsies. Three underwent surgery, leading to the diagnoses of gastrointestinal stromal tumor (GIST), adrenocortical adenoma and retroperitoneal Castleman disease.

One iatrogenic complication related to IFs occurred (an acute urinary retention following the radiofrequency ablation of the Bosniak category IV cystic renal lesion; the patient's whose hospital stay was extended by one day).

The total cost of additional investigations and procedures was €41,247 (of which €24,963 was for in-hospital care) with an average of €2,578 per patient followed (including the two patients followed up with non-clinically significant IFs): *table IV, supplementary material III*.

Two diagnoses of malignancy were made, namely a low risk GIST of Fletcher's classification in a healthy 49-year-old woman (histologically proven) and a Bosniak IV cystic renal lesion (histologic sample was inconclusive) in a 73-year-old man who died from another cancer.

Table IV: Additional investigations, costs and final diagnoses (with invasive procedures)

Patient	Incidental finding	Invasive procedures	Total cost of investigations	Final diagnosis
49 y/o woman	Gastric mass of 3 cm	Echoendoscopic gastric biopsy Partial gastric resection	€10,191	Gastrointestinal stromal tumor (considered cured 7 years later)
77 y/o man	Probable pancreatic cystadenoma of 2 cm 2-centimeter kidney nodules	Echoendoscopic pancreatic cytopuncture	€1,735	"No malignant cell" Both IFs stable for 8 years
40 y/o woman	Liver nodule of 2 cm	CT-guided liver biopsy	€3,442	"Subnormal liver tissue" Stable for 4 years
52 y/o woman	Adrenal mass of 2 cm	Adrenalectomy	€7,864	Adrenocortical adenoma
73 y/o man	Bosniak IV kidney cyst of 13 mm	CT-guided kidney biopsy and radiofrequency ablation at the same time	€2,895	Inconclusive histology (died 4 years later from a periampullary carcinoma)
33 y/o man	Retroperitoneal mass of 9 cm with pulmonary micronodules	CT-guided retroperitoneal biopsy Surgical resection	€5,997	Castleman disease (pulmonary micronodules stable for 3 years)
59 y/o man	Incidental prostatic uptake on a PET-CT performed for incidental pulmonary nodules	Ultrasound-guided prostatic biopsies	€1,546	Chronic prostatitis Pulmonary nodules stables for 2 years

CT: computed tomography. IF: incidental finding. PET: positive emission tomography. y/o: year-old.

DISCUSSION AND CONCLUSION

In this study, IFs on emergency MDCTs were frequent (11% of brain MDCTs, and 28% of non-brain CT scans), but rarely severe (only two malignant diagnoses), rarely iatrogenic (only one documented benign complication) and relatively expensive (average cost of €2,578 per patient followed).

In the literature, most of the other studies were focused on only one body area or one type of indication. However, comparing results by body area or indication to studies with a similar methodology, our results are close to the literature. In Anjum et al.'s study [14], 13% (223/1708) of patients with suspected pulmonary embolism had at least one IF versus 12% (21/171) in our study. In abdominopelvic emergency MDCTs, 35% (148/425) of our patients had at least one IF, versus 42% (1155/2745) in Kelly et al.'s study [7].

With respect to the predictive factors of IFs, the junior radiologists' propensity to describe IFs was higher than that of senior radiologists. It is interesting to see that the difference was smaller for IFCSs (OR = 2.2 versus OR = 1.8). Our assumptions are that younger radiologists are less confident about what is of low or high clinical significance and that they need to prove their reliability to their correspondents.

We also showed that abdominopelvic radiologists described more IFs in their own specialty than other radiologists (OR = 1.9), with a higher effect when limiting to IFCSs (OR = 2.5). There seems to be an added value in being a specialist in differentiating important incidentalomas from others [21].

We did not show any significant difference in the rate of IFs regarding the time of day and the presence of an abnormality supposedly related to the patient's symptomatology. This reflects the systematic way that radiologists analyze scanners and leads to more IFs.

The absence of prior CT scanner was a significant predictive factor for the presence of an IF (OR = 2.1). However, we did not show such an association concerning IFCSs. This draws attention to the fact that IFCSs were evolutive abnormalities and were well classified.

The overall report rate of IFs in emergency discharge paperwork was low in our study (26% (87/333) for all IFs, 37% (55/150) for IFCS) but higher than or similar to what is observed in the literature (10% (34/448) for Thompson et al. [18] and 27% (69/253) for Munk et al. [22]). The first explanation is probably that radiologists focused their provisional report on the initial indication and described IFs in the final report. The second explanation is that the overwork of emergency physicians does not let them deal with IFs as much as they would like. However, there was no significant difference in the report rate regarding the time of day or the age of the patients. This reflects the constant work of emergency physicians. The low reporting rate of IFs in the emergency discharge paperwork indicates an area for improvement. In this regard, Baccel et al. evaluated in 2018 a specific workflow for IFs on emergency room imaging in which a nurse had to ensure that the IFs were reported in the emergency discharge paperwork, with good results on the follow-up rate of IFs [23].

Regarding the final diagnoses, Kelly et al. [7] reported a diagnosis of cancer in 2% (24/1155) of emergency abdominopelvic MDCTs (versus 0.5% (2/425) in our study). This difference could appear surprising because methodologies were similar (retrospective study, including all indications, in a tertiary referral university-affiliated hospital). However, we hypothesize that the younger median age of the patients in our study (42 years old for abdominopelvic MDCTs, versus 57 years old) and the lower incidence of cancers in our administrative department (360/100,000 persons per year [24], versus 428/100,000 in the county of Kelly et al.'s study [25]) could be the main explanations of the lower rate of cancer in our study.

Concerning the cost of additional care related to IFs, to our knowledge, no study dealing with the overall emergency CT scans has assessed real costs of follow-ups on IFs. Furthermore, costs and side effects of IFs must be balanced with the costs and morbidity of a late disclosure of a severe diagnosis at a symptomatic stage. For example, the GIST incidentally discovered at a low risk stage in the 49-year-old woman would have been more expensive and a source of morbidity if revealed a few years later. Nevertheless, if the follow-up rate of IFs was higher, the cost might exceed that of chemotherapy. The benefit / risk ratio is even more uncertain. Even if it seems favorable in our study (which does not have the necessary statistical power for this conclusion), this is less evident in Morgan's study for example (2 deaths following IFs in 143 patients) [8]. This is difficult to study because it would raise methodological and ethical issues [10]. Beyond reporting non-pertinent IFs, the real problem is unnecessary investigations (because of side effects, costs and anxiety of the patients). A good way to deal with this issue would be to continue to apply the principle whereby the radiologist is responsible for looking for and describing all abnormalities present on each MDCT slice, even those unrelated to the chief complaint, but minimizing the prevalence of IFs by ordering only necessary CT scans [3] and following point-of-care reference materials to manage the IFs [26], such as suggested by the white papers of the American College of Radiology Incidental Findings Committee [15]. This would avoid the vicious circles in which the exploration of an IF leads to the finding of a new incidentaloma.

Our study dealt with 2011 data that could appear out-of-date. However, our CT scan was put into service in 2010. Thus, we got a long follow-up of IFs while having data acquired on an updated machine. But the main limitation of our study is that a follow-up investigation was available only for patients who chose our institution for additional investigations (11%, 14/122). We might miss a significant part of patients in our results, but we can imagine that if severe diagnoses related to these IFs were made outside our hospital, they would have

been referred and treated in our institution and therefore we would have had a record of them. Even beyond our study, the rate of follow-up is always low in the literature: 19.4% reported by van Vugt in 2012 [6] and 26.9% by Munk in 2010 [22]. The main reason is probably that a significant part of patients come to tertiary referral university-affiliated hospitals for emergency situations but choose their usual primary care centers for non-emergency additional investigations. However, it can also highlight the lack of transmission of incidental findings and 'medical nomadism.'

In conclusion, IFs on emergency MDCTs were frequent, but rarely severe, rarely iatrogenic and relatively expensive. Costs and side effects of additional investigations could be minimized by following point-of-care reference materials without reducing the rate of detecting relevant incidental findings.

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SUPPLEMENTARY MATERIALS

a) Supplementary Material I: Items not recorded as incidental findings

Area	Item
Head	Cerebral hypotrophy related to age Vascular leukoencephalopathy Basal ganglia calcifications Common mucosal thickening of maxillary sinus
Chest	Nonspecific fibrous scarring in the apical pulmonary parenchyma Calcified lung granuloma Gravity dependent, cicatricial or passive atelectasis Tracheobronchial calcifications
Abdomen	Common hepatic perfusion defect of segment IVb Accessory spleen Colon fecal impactions
Pelvis	Pelvic phleboliths
Blood vessels	Non-stenosing atherosclerotic plaques
Skeletal	Accessory ossicles Anatomical variations in the bony spine Bone callus Common degenerative spine changes Acromioclavicular joint arthrosis

b) Supplementary Material II: Full list of incidental findings

Head and Neck

IF (n=20)	Number (n=55)	IFCS (n=10)	Mean age (SD)	Sex (female/male) (25/30)	Report in the EDP (n=12)	Available follow-up (n=3)
Head						
Brain injuries	15	no	80.0 (18.7)	9/6	2	1
Arachnoid cyst	3	no	42.3 (37.1)	1/2	0	0
Cavum septum pellucidum cyst	3	no	48.3 (11.9)	0/3	0	0
Hydrocephalus	2	yes	72.5 (3.5)	1/1	0	0
Cerebellopontine angle tumor	1	yes	63	1/0	1	0
Platybasia	1	no	85	1/0	0	0
Mega cisterna magna	1	no	41	0/1	0	0
Asymmetry of the lateral ventricles	1	no	51	0/1	0	0
Colloid cyst	1	no	31	0/1	1	0
Choroid plexus cyst	1	no	27	0/1	1	0
Subcutaneous nodule	1	yes	40	1/0	0	0
Opacified sinus	14	no	37.1 (20.2)	5/9	4	0
Sinus hypoplasia	1	no	52	1/0	0	0
Dental implant-related maxillary sinusitis	1	yes	18	0/1	0	0
Appearance of fungal sinusitis	1	yes	74	1/0	1	1
Neck						
Salivary gland stones	1	no	50	0/1	0	0
Thyroid cyst	1	no	55	1/0	1	0
Thyroid nodule > 15 mm	3	yes	61.7 (23.5)	1/2	1	1
Thyroid nodule < 15 mm	2	no	49.0 (39.6)	1/1	0	0
Goiter	1	yes	87	1/0	0	0

Chest

IF (n=17)	Number (n=48)	IFCS (n=33)	Mean age (SD)	Sex (female/male) (19/29)	Report in the EDP (n=12)	Available follow-up (n=3)
Lung						
Nodule	13	yes	57.0 (19.0)	5/8	6 (2 md)	2
Emphysema	9	no	42.0 (11.7)	1/8	0	0
Peribronchial cuffing	4	no	69.8 (17.3)	3/1	0	0
Parenchymal opacification	4	yes	78.5 (7.5)	1/3	2	0
Pulmonary edema	1	yes	64	0/1	md	0
Proximal bronchial stenosis	1	yes	33	1/0	0	0
Bronchiolitis	1	yes	73	0/1	0	0
Pleura						
Effusion	5	yes	59.0 (18.2)	3/2	0	0
Thickening	1	yes	48	0/1	0	0
Calcifications	1	no	56	0/1	1	1
Nodule	1	yes	55	0/1	0	0
Mediastinum						
Adenopathy	1	yes	33	1/0	0	0
Cardiomegaly	1	yes	67	1/0	0	0
Paravertebral mass	1	yes	74	0/1	1	0
Teratoma	1	yes	59	1/0	1	0
Ascending aortic aneurysm	2	yes	57.5 (40.3)	1/1	1	0
Arteria lusoria	1	no	84	1/0	0	0

Abdomen-pelvis

IF (n=60)	Number (n=221)	IFCS (n=100)	Mean age (SD)	Sex (female/male) (111/110)	Report in the EDP (n=60)	Available follow-up (n=12)
Liver						
Simple cyst	19	no	54.1 (18.4)	12/7	0	0
Nodule	14	yes	49.6 (17.4)	6/8	6	2
Steatosis	12	yes	51.1 (12.8)	2/10	2 (1 md)	0
Hepatomegaly	9	yes	33.4 (15.6)	7/2	3	0
Hemangioma	8	no	44.5 (13.3)	4/4	3	0
Dysmorphia	4	yes	57 (9.1)	0/4	2	0
Periportal edema	2	yes	56 (11.3)	0/2	1 (1 md)	0
Complex cyst	2	yes	68 (22.7)	1/1	2	1
Calcification	2	no	81.5 (6.4)	0/2	0	0
Hepatic perfusion disorder	1	yes	54	0/1	0	0
Biliary tract						
Stones	11	no	60.8 (23.4)	7/4	3	0
Dilatation	6	yes	58.7 (14.5)	5/1	0	0
Porcelain gallbladder	1	no	74	1/0	0	0
Gallbladder sludge	1	no	32	1/0	0	0
Pancreas						
Cyst	3	yes	66 (11.4)	2/1	2	1
Atrophy	3	no	72 (2.6)	2/1	0	0
Main duct dilatation	2	yes	81 (1.4)	0/2	1	0
Calcifications	2	no	81 (1.4)	0/2	0	0
Cystadenoma	1	yes	77	0/1	1	1
Spleen						
Splenomegaly	2	yes	31 (14.1)	0/2	1	0
Hepatosplenomegaly	2	yes	63 (12.7)	0/2	0	0
Calcification	1	no	64	0/1	0	0
Hemangioma	1	no	71	1/0	0	0
Adrenal gland						
Mass	7	yes	54 (15.0)	3/4	1	2
Hypertrophy	3	yes	81.7 (5.0)	2/1	2	0
Calcification	2	no	22.5 (2.1)	2/0	0	0
Kidney						
Bosniak I cyst	29	no	64 (18.6)	11/18	5	0
Bosniak II cyst	2	no	53 (15.6)	0/2	1	0
Bosniak IIF cyst	1	yes	66	1/0	1	0
Bosniak IV cyst	1	yes	73	0/1	1	1
Cortical scars	8	no	64.9 (20.1)	6/2	2	0
Nodule	2	yes	61 (22.6)	0/2	1	2

IF (n=60)	Number (n=221)	IFCS (n=100)	Mean age (SD)	Sex (female/male) (111/110)	Report in the EDP (n=60)	Available follow-up (n=12)
Stones	2	yes	38.5 (20.5)	1/1	0	0
Pyelonephritis	1	yes	83	1/0	1	0
Calcifications	1	no	77	0/1	0	0
Urinary tract						
Dilatation	3	yes	61 (5.2)	2/1	1	0
Bladder diverticula and stones	1	yes	83	0/1	md	0
Uterus						
Fibroid	4	no	64 (16.4)	4/0	1	0
Ovary						
Cyst	5	yes	46.6 (21.9)	5/0	2	0
Mass	1	yes	36	1/0	1	0
Colon						
Diverticula	10	no	60.8 (18.0)	4/6	2	0
Sclerolipomatosis	2	no	52.5 (9.2)	1/1	1	0
Stomach						
Paragastric cyst	1	yes	66	1/0	1	0
Mass	1	yes	49	1/0	1	1
Hiatal hernia	4	no	77.3 (9.7)	3/1	1	0
Lymph nodes						
Mesenteric adenopathy	2	yes	58.5 (38.9)	0/2	0	0
Inguinal adenopathy	1	yes	71	1/0	0	0
Abdominal wall						
Umbilical hernia	1	yes	82	1/0	0	0
Inguinal hernia	3	yes	66.7 (25.5)	0/3	1	0
Subcutaneous infiltration	1	yes	75	1/0	1	0
Blood vessels						
Aortic aneurysm	1	yes	90	1/0	1	0
Pelvic varicose veins	2	no	62.5 (6.4)	2/0	1	0
Retroaortic left renal vein	1	no	33	1/0	0	0
Left renal vein dilatation	1	no	22	0/1	0	0
Femoral vein duplication	1	no	46	1/0	0	0
Other						
Prostatomegaly	3	no	71 (13.7)	0/3	1	0
Peritoneal calcifications	1	no	58	1/0	0	0
Retroperitoneal mass	1	yes	33	0/1	1	1
Ileitis	1	yes	21	1/0	1	0
Hydrocele	1	no	75	0/1	0	0

Skeletal

IF (n=8)	Number (n=16)	IFCS (n=7)	Mean age (SD)	Sex (female/male) (4/12)	Report in the EDP (n=3)	Available follow-up (n=0)
Spine						
Compression fracture	3	yes	63.3 (24.8)	2/1	2	0
Isthmic spondylolisthesis	3	no	49 (30.0)	0/3	0 (1 md)	0
Osteoblastic lesions	1	yes	81	0/1	0	0
Tarlov cyst	1	no	59	1/0	0	0
Limbs						
Enostosis	4	no	38.8 (16.3)	1/3	0	0
Bone cyst	2	yes	41.5 (7.8)	0/2	0	0
Osteochondroma	1	yes	22	0/1	0	0
Chondrocalcinosis	1	no	77	0/1	1	0

Total

Number of different IFs	Number of IFs	Number of IFCSs	Mean age (SD)	Sex (female/male)	Report in the EDP	Available follow-up
105	340	150	57.3 (20.6)	159/181	87 (7 md)	18

EDP: emergency discharge paperwork. IF: incidental finding. IFCS: incidental finding of high clinical significance. md: missing data. SD: standard deviation.

c) Supplementary Material III: Detailed additional investigations and costs

III.a: with invasive procedures

Patient	Incidental findings	Procedures	Costs
49 y/o woman	Gastric mass of 3 cm	*In-hospital care:*	
		Echoendoscopy (1-day stay)	€723
		Echoendoscopic gastric biopsy (1-day stay)	€707
		Partial gastric resection (4-day stay)	€7,443
		Out-of-hospital care:	
		10 consultations	€284
		Biological tests	€17
		6 MDCTs	€683
		1 MRI	€321
		1 echoendoscopy	€113
		Total:	**€10,191**
77 y/o man	Probable pancreatic cystadenoma of 2 cm 2-centimeter kidney nodules	*In-hospital care:*	
		Echoendoscopic pancreatic cytopuncture (1-day stay)	€707
		Out-of-hospital care:	
		4 consultations	€92
		1 ultrasonography	€36
		1 contrast-enhanced ultrasonography	€56
		6 MDCTs	€642
		1 MRI	€202
		Total:	**€1,735**
40 y/o woman	Liver nodule of 2 cm	*In-hospital care:*	
		CT-guided liver biopsy (2-day stay)	€1,437
		Out-of-hospital care:	
		3 consultations	€81
		Biological tests	€88
		1 ultrasonography	€38
		5 MRIs	€985
		1 PET-CT	€813
		Total:	**€3,442**
52 y/o woman	Adrenal mass of 2 cm	*In-hospital care:*	
		3-day stay for additional investigations	€1,771
		Adrenalectomy (11-day stay)	€5,527
		Out-of-hospital care:	
		3 consultations	€75
		Biological tests	€304
		1 MDCT	€187
		Total:	**€7,864**
73 y/o man	Bosniak IV kidney cyst of 13 mm	*In-hospital care:*	
		CT-guided kidney biopsy and radiofrequency ablation at the same time (2-day stay)	€1,953
		Out-of-hospital care:	
		4 consultations	€114
		Biological tests	€19
		4 MRIs	€809
		Total:	**€2,895**
33 y/o man	Retroperitoneal mass of 9 cm with pulmonary micronodules	*In-hospital care:*	
		Surgical resection (8-day stay)	€5,702
		Out-of-hospital care:	
		3 consultations	€81
		Biological tests	€34
		CT-guided retroperitoneal biopsy	€155
		Anatomopathology	€25
		Total:	**€5,997**
59 y/o man	Incidental prostatic uptake on a PET-CT performed for incidental pulmonary nodules	*Out-of-hospital care:*	
		9 consultations	€145
		Biological tests	€23
		1 prostatic enchoendoscopy	€36
		Ultrasound-guided prostatic biopsies	€54
		Anatomopathology	€43
		4 MDCTs	€432
		1 PET-CT	€813
		Total:	**€1,546**

III.b: without invasive procedure

Patient	Incidental findings	Procedures	Costs
33 y/o man	Lacunar white matter hypodensities	*Out-of-hospital care:*	
		2 consultations	€71
		1 MRI	€251
		Total:	**€322**
74 y/o woman	Appearance of fungal sinusitis	*Out-of-hospital care:*	
		1 consultation	€16
		Total:	**€16**
88 y/o man	Thyroid nodule of 3 cm	*Out-of-hospital care:*	
		1 consultation	€16
		Biological tests	€23
		Total:	**€39**
56 y/o man	Pleural calcifications	*Out-of-hospital care:*	
		1 consultation	€16
		1 pulmonary function test	€28
		1 conventional radiography	€15
		Total:	**€59**
72 y/o man	Liver hypodensities	*Out-of-hospital care:*	
		1 MRI	€202
		Biological tests	€19
		Total:	**€221**
84 y/o woman	Non-enhancing high-attenuation and calcified liver cysts	*Out-of-hospital care:*	
		1 consultation	€35
		Biological tests	€104
		Total:	**€139**
71 y/o woman	Pancreatic cyst	*In-hospital care:*	
		1 echoendoscopy (1-day stay)	€707
		Out-of-hospital care:	
		3 consultations	€105
		1 MDCT	€186
		3 MRIs	€606
		Total:	**€1,604**
62 y/o woman	Adrenal mass of 3 cm	*In-hospital care:*	
		7-day stay for additional investigations	€2,042
		3-day stay for additional investigations	€1,771
		Out-of-hospital care:	
		1 consultation	€16
		Biological tests	€111
		3 MDCTs	€332
		1 scintigraphy	€126
		Total:	**€4,398**
45 y/o man	Kidney nodule of 2 cm	*Out-of-hospital care:*	
		4 MRIs	€779
		Total:	**€779**

CT: computed tomography. MDCT: multidetector computed tomography. MRI: magnetic resonance imaging. PET: positive emission tomography. y/o: year-old.

BERGE Pierre

Découvertes fortuites sur les scanners d'urgences : facteurs prédictifs et impact médico-économique

RÉSUMÉ

Objectif : L'objectif principal était d'évaluer les types et les facteurs prédictifs des découvertes fortuites (DF) sur les scanners réalisés pour un service d'urgences. L'objectif secondaire était d'analyser les explorations complémentaires, leurs bénéfices, effets secondaires, coûts et les diagnostics finaux.

Méthode : Mille patients consécutifs de plus de 18 ans ayant passé un scanner au service d'urgences de notre hôpital entre janvier et novembre 2011 ont été rétrospectivement inclus, soit un total de 1000 scanners dont 300 scanners cérébraux. Les paramètres suivants ont été recueillis dans les dossiers-patients informatisés : découvertes fortuites (classées en cliniquement significatives et cliniquement non significatives), parties du corps explorées, disponibilité d'une imagerie antérieure, expérience et spécialité du radiologue, explorations complémentaires ainsi que leurs résultats et coûts.

Résultats : Parmi les 1000 patients inclus, 232 avaient au moins une DF, qui était significative chez 122 patients. On totalisait 340 DF dont 150 significatives. Une association statistiquement significative avec la présence d'au moins une DF était observée pour : l'âge élevé du patient, l'expérience moindre du radiologue, l'absence de spécialité du radiologue, la région abdominopelvienne et l'absence d'imagerie antérieure. Dix-huit DF ont généré des explorations complémentaires dans notre hôpital, notamment cinq biopsies et trois chirurgies, aboutissant au diagnostic de deux cancers (une tumeur stromale gastro-intestinale et un kyste rénal Bosniak IV). Une complication iatrogène bénigne est survenue. Le coût total de ces investigations était chiffré à 41 247 €, soit une moyenne de 2 292 € par découverte fortuite explorée.

Conclusion : Les découvertes fortuites sur les scanners d'urgences étaient fréquentes, rarement sévères, rarement iatrogènes et relativement coûteuses.

Mots-clés : découvertes fortuites, service d'urgences, tomodensitométrie, significativité clinique, rapport bénéfice-risque, rapport coût-efficacité

Incidental Findings on Emergency CT scans: predictive factors and medico-economic impact

ABSTRACT

Purpose: The main objective was to evaluate types and predictive factors of incidental findings (IFs) on multidetector computed tomographies (MDCTs) performed for an emergency department (ED). The secondary aim was to analyze additional investigations, their benefits, side effects, costs and the final diagnoses.

Method: One thousand consecutive patients over 18 years old who underwent an MDCT in the ED of our institution from January 2011 to November 2011 were retrospectively included, accounting for 300 head MDCTs and 700 other MDCTs. The following criteria were collected in patient electronic medical records: IFs (divided into low and high clinical significance), body areas covered, availability of a prior imaging, radiologist's experience and subspecialty, additional investigations, their outcomes and costs.

Results: Among the 1000 included patients, 232 had at least one IF and 122 had at least one IF of high clinical significance (IFCS). There were 340 IFs and 150 IFCSs. A significant association with the presence of at least one IF was noted for older patients, less-experienced radiologists, no subspecialty of the radiologist, the abdominopelvic area, and the absence of prior imaging. Eighteen IFs generated additional investigations in our institution, including five invasive samplings and three surgical operations, with two diagnoses of malignancy (a gastrointestinal stromal tumor and a Bosniak IV cystic renal lesion). One benign iatrogenic complication occurred. Total cost of these investigations was €41,247 (with an average of €2,292 per IF investigated).

Conclusion: IFs on emergency MDCTs were frequent, rarely severe, rarely iatrogenic and relatively expensive.

Keywords: incidental findings, emergency department, computed tomography, clinical significance, risk-benefit ratio, cost-effectiveness ratio

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