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Incidences and reporting rates of incidental findings on lumbar, thoracic, and cervical spinal magnetic resonance images and extra-neuronal findings on brain magnetic resonance images

Volkan Kızılgöz[1], Hasan Aydın[2], Ali Kemal Sivrioğlu[3], Ümit Can Özcan[1], Utku Menderes[4], Sunay Sibel Karayol[1], Ahmet Erdem[1]

[1]Department of Radiology, Kafkas University School of Medicine, Kars, Turkey
[2]Department of Radiology, Abdurrahman Yurtaslan Ankara Oncology Training and Research Hospital, Ankara, Turkey
[3]Department of Radiology, Okmeydanı Training and Research Hospital, İstanbul, Turkey
[4]Department of Radiology, Eskişehir State Hospital, Eskişehir, Turkey

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ABSTRACT

Objective: This study aimed to evaluate the incidence rates, reporting rates, and the best imaging plane and sequence for incidental findings in patients undergoing spinal and brain magnetic resonance (MR) imaging.
Methods: Three experienced radiologists retrospectively re-evaluated the MR images of 1056 consecutive patients.
Results: The incidence rates for extraspinal incidental findings for the images of the lumbar, thoracic, and cervical spine, and extra-neuronal incidental findings on MR images of the brain were 35.47%, 32.25%, 29.16%, and 54.35%; respectively, with reporting rates of incidental findings for these examinations of 31.47%, 8.33%, 29.50%, and 59.62%; respectively. For all examination types, the T2-weighted sequence and the axial plain were the best to reveal the incidental findings of MR examinations, other than that of the cervical spine.
Conclusions: Incidental findings, which are commonly detected during routine spinal and brain MR evaluations, are occasionally omitted from formal radiological reports in daily practice. We strongly recommend checking the T2-weighted axial plane for MR imaging of the lumbar, thoracic spine and brain and taking a second look at the T2-weighted sagittal plane MR images of the cervical spine during radiological evaluations.

Keywords: Incidental findings, magnetic resonance imaging, spine, brain, report

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Magnetic resonance imaging (MRI) of the lumbar, thoracic, and cervical spine, as well as the brain is a routine procedure in radiological examinations. The majority of focused diagnostic issues associated with back pain, neck pain, and positive physical examination results indicating radiculopathy include disc hernias, spinal lesions, and degenerative changes of the vertebral column. Brain MRI is useful to diagnose the possible causes of headache, dizziness, cognitive function disorders, demyelinating disorders, vascular malformations, and aberrant physical examination results due to stroke, infection, trauma, and tumor formation. A physical examination is crucial to evaluate patient complaints and is very important to

Address for correspondence: *Volkan Kızılgöz, MD., Kafkas University School of Medicine, Department of Radiology, Mimar Kars, Turkey*
E-mail: volkankizilgoz@gmail.com

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determine whether MRI would be beneficial to arrive at a diagnosis. Incidental findings are defined as previously undiagnosed and unintentionally encountered medical conditions that are unrelated to the current medical condition for which tests are being performed or the patient is being treated. These findings range from abnormalities of potential clinical disorders relevant to the main underlying pathology or accidentally discovered problems that are unrelated to the main purpose of the MR examination. This study investigated the incidence rates and reporting rates, as well as the best imaging MR plane and sequence in order to reveal incidental findings on spinal and brain MR images.

METHODS

The protocol of this retrospective study was approved by a local Ethics Committee. Due to the methodology and design of the study, the requirement for informed consent was waived. Lumbar, thoracic, and cervical spinal MR images, and brain MR images of 1056 consecutive patients [489 (46.30%) males and 567 (53.69%) females; mean age, 50.11 years; age range, 4-96 years] from examinations conducted between June 1 and September 30, 2016 were retrieved from the picture archive and communication system (PACS) (MediPlus PACS; Turmap Information Technologies, Ankara, Turkey) of our hospital and were reinterpreted for the occurrence of incidental findings.

Interpretation

MR images of each patient were separately reinterpreted by three radiologists (a musculoskeletal radiologist with 11 years of experience and two neuroradiologists with 14 and 15 years of experience), and incidental findings were ascertained by the consensus of at least two of the interpreters. Medical conditions that were visible on MR images, but were unrelated to the current clinical information or prediagnosis of the patient's condition for which medical tests had been performed or had been treated were accepted as incidental findings. The incidental findings comprised lesions, anatomical variants, and anomalies. After the MRI evaluation, the prediagnostic information given by the clinician and the incidental findings of the patients were determined and former radiology reports were reviewed to determine whether the incidental finding had been noticed. Additionally, the best MRI sequence and plane that revealed the incidental findings were determined by the consensus of at least two of the three reviewers. The MRI sequence that best depicted lesion contours and revealed a visual contrast of the lesion was accepted as the best sequence. The MRI plane in which the anomaly and anatomical variance of the lesion were entirely or almost entirely visible and the one that indicated the specific morphology or radiological appearance of the incidental findings better was accepted as the best plane. Scout images were also examined in addition to other routine sequences. Incidence rates were calculated as the ratio of the number of patients to all examined patients. Extraspinal and extraneuronal findings were classified by organ or system, and the incidence rate of each finding was calculated separately. Hemangiomas, vertebral anomalies, and fractures were not considered as incidental findings in this study because these conditions are commonly located very near to discs and are easily noticed in daily clinical practice. For brain MRI, 24 mild nasal septal deviations and spur formations, which caused obvious blockage of air flow in the nasal passage, were excluded from analysis. Among the patients with MRI of the cervical spine, four were excluded from the study due to the presence of primary malignancies involving larger lymphadenopathies than those mentioned in the corresponding clinical report.

MR Imaging

A Magnetom Essenza 1.5T MRI system (Siemens Healthcare GmbH, Erlangen, Germany) was used to obtain all images. Cervical, thoracic, and lumbar spinal examinations were performed using an 8-channel spinal coil, and brain MR examinations were performed using an 8-channel head coil. The routine cervical spinal MR protocol included sagittal T1-weighted, sagittal T2-weighted, and axial T2-weighted sequences. The thoracic spinal MR protocol included sagittal T1-weighted, sagittal T2-weighted, and axial

T2-weighted sequences. The lumbar spinal MR protocol included sagittal T1-weighted, sagittal T2-weighted, and axial T2-weighted sequences. Brain MR images included axial T1-weighted, axial T2-weighted, axial fluid attenuation inversion recovery (FLAIR), sagittal FLAIR, and coronal T2-weighted sequences. The scout images for cervical, thoracic, lumbar spinal MRI and brain MRI were also obtained before the routine imaging sequences. The axial section images were taken between the L1 and S1 vertebrae for lumbar MR imaging, between the T1 and T12 vertebrae for thoracic imaging, and between the C2 and C7 vertebrae for cervical imaging. The pre-saturation band was only applied in sagittal series for spinal imaging.

Statistical Analysis

The frequencies of incidental findings, the organ or system which the incidental was located, reporting rates, best imaging plane and best MRI sequences to visualize the incidental finding were expressed as the number of cases and correspondent percentages.

RESULTS

Lumbar Spinal MRI

The mean age of patients with incidental findings on MR imaging of the lumbar spinal (n = 210) was 51.63 (range, 15-85) years. Of these 210 patients, 87 (41.42%) were males and 123 (58.57%) were females.

Incidental findings were observed on 35.47% of the MR images of the lumbar spinal (Table 1) with renal cyst formation being the most common (43.42% of all incidental findings) and 64 (58.7%) of all 109 patients with this incidental finding were not reported in routine practice (reporting rate of 41.28%).

Of all incidental findings on lumbar spinal MR images, the kidney was the most commonly affected organ with findings of extra spinal involvement (64.94%). The incidences of renal stones, renal atrophies, an extra renal pelvis, left accessory renal arteries, and solitary kidneys were most commonly overlooked in the radiology reports. Hepatomegaly, splenomegaly, choledochal ecstasies, Nabothian cysts, and paraaortic lymphadenopathy were also commonly missed. For lumbar MRI examinations, hepatomegaly was only discerned on scout images. Localizer views were also the best sequence to reveal splenomegaly and prostate enlargement. All cases of horseshoe kidney, renal sinus lipomatosis, renal mass, focal renal caliectasis, diverticulosis of the colon, paravertebral soft tissue abscess, and ovarian mass were appropriately cited in the radiology reports.

The reporting rate of incidental findings on lumbar spinal MR images was 31.47%. The best sequence to detect incidental findings on these images was the T2-weighted sequence (78.08%) and axial planes (70.11%) were better than sagittal views (Table 2) (Figures 1, 2, 3, and 4).

Thoracic Spinal MRI

The mean age of patients with incidental findings on spinal MR images of the thoracic region (n = 10) was 32.40 (range, 4-83) years and half of these patients were male. The incidence rate for this examination was 32.25% (Table 1). The incidental findings were mostly related to the lungs and pleura (50%). Pleural effusion was the most common incidental finding with an incidence rate of 25% and

Table 1. Incidence rates of each MRI examination included in this study

Examination	Number of patients	Number of incidental findings	Number of patients with incidental findings	Incidence rate (%)
Lumbar MRI	592	251	210	35.47
Thoracic MRI	31	12	10	32.25
Cervical MRI	192	61	56	29.16
Brain MRI	241	162	131	54.35
TOTAL	1056	486	407	38.54

Table 2. Incidental extraspinal findings of lumbar spine MR imaging

Incidental finding	Related organ/system	Number (%)	Incidence Rate (%)	Reported	Unreported	Reporting rate (%)	Best sequence*	Best imaging plane*
Cyst	Kidney	109 (43.42)	18.41	45	64	41.28	T2 (81 of 109)	AX (96 of 109)
Retroaortic left renal vein	Kidney	24 (9.56)	4.05	1	23	4.16	T2 (24 of 24)	AX (24 of 24)
Stones	Kidney	2 (0.79)	0.33	0	2	0	T2 (2 of 2)	AX (2 of 2)
Atrophy	Kidney	2 (0.79)	0.33	0	2	0	T2 (2 of 2)	AX (2 of 2)
Horseshoe kidney	Kidney	1 (0.39)	0.16	1	0	100	T2 (1 of 1)	AX (1 of 1)
Left accessory renal artery	Kidney	2 (0.79)	0.33	0	2	0	T2 (2 of 2)	AX (2 of 2)
Renal sinus lipomatosis	Kidney	1 (0.39)	0.16	1	0	100	T2 (1 of 1)	AX (1 of 1)
Extrarenal pelvis	Kidney	6 (2.39)	1.01	0	6	0	T2 (4 of 6)	AX (4 of 6)
Hydronephrosis	Kidney	8 (3.18)	1.35	5	3	62.50	T2 (8 of 8)	AX (8 of 8)
Renal malrotation	Kidney	4 (1.58)	0.67	0	4	0	T2 (4 of 4)	AX (4 of 4)
Renal mass	Kidney	1 (0.39)	0.16	1	0	100	T2 (1 of 1)	AX (1 of 1)
Focal renal caliectasis	Kidney	1 (0.39)	0.16	1	0	100	T2 (1 of 1)	AX (1 of 1)
Solitary kidney	Kidney	2 (0.79)	0.33	0	2	0	T2/SC (1 of 2)	AX/COR (1 of 2)
Gallbladder stone	Gallbladder	4 (1.59)	0.67	2	2	50	T2 (4 of 4)	AX (3 of 4)
Hepatomegaly	Liver	4 (1.59)	0.67	0	4	0	SC (4 of 4)	COR (4 of 4)
Hepatic cyst	Liver	3 (1.19)	0.50	1	2	33.33	SC (2 of 3)	COR (2 of 3)
Hepatic mass	Liver	2 (0.79)	0.33	2	0	100	T2 (2 of 2)	AX (2 of 2)
Splenomegaly	Spleen	1 (0.39)	0.16	0	1	0	SC (1 of 1)	COR (1 of 1)
Choledochal ectasia	Biliary system	2 (0.79)	0.33	0	2	0	T2 (2 of 2)	AX (2 of 2)
Wall thickening	Bladder	8 (3.18)	1.35	1	7	12.50	T2 (7 of 8)	AX (6 of 8)
Nabothian cyst	Cervix	3 (1.19)	0.50	0	3	0	T2 (2 of 3)	SAG (3 of 3)
Myoma	Uterus	10 (3.98)	1.68	2	8	20	T2 (10 of 10)	SAG (9 of 10)
Retroverted Uterus	Uterus	22 (8.76)	3.71	2	20	9.09	T2 (15 of 22)	SAG (21 of 22)
Diverticulosis	Colon	1 (0.39)	0.16	1	0	100	T2 (1 of 1)	AX (1 of 1)
Paraaortic lymphadenopathy	Lymphatic system	1 (0.39)	0.16	0	1	0	T2 (1 of 1)	AX (1 of 1)
Pelvic free fluid	Pelvic cavity	4 (1.59)	0.67	2	2	50	T2 (4 of 4)	SAG (3 of 4)
Cyst	Ovaries	20 (7.97)	3.37	9	11	45	T2 (15 of 20)	AX (13 of 20)
Ovarian mass	Ovaries	1 (0.39)	0.16	1	0	100	T2 (1 of 1)	AX (1 of 1)
Enlarged prostate	Prostate	2 (0.79)	0.33	1	1	50	SC (2 of 2)	SAG (2 of 2)
TOTAL	**Kidney# (64.94%)**	**251 (100)**	**35.47**	**79**	**172**	**31.47**	**T2# (78.08%)**	**AX# (70.11%)**

*Indicates the MR sequence and imaging plane that best depicts the incidental finding. Numbers in parenthesis (… of …) indicate the frequencies of certain incidental finding revealed by the best sequence or best plane among all MR sequences or planes. **#Indicates the organ/system, best sequence, or the best imaging plane which the incidental findings of lumbar spine MR imaging is mostly seen.**

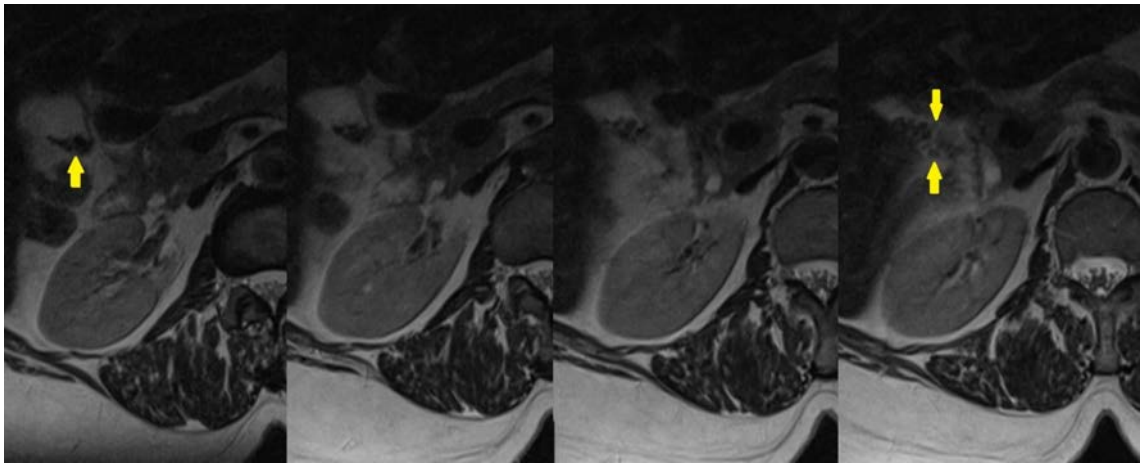

Figure 1. Lumbar spinal MR images of a 61-year-old female. Consecutive axial T2-weighted images of the patient indicate incidental gallbladder stones (yellow arrows). The diagnosis was confirmed by ultrasonography

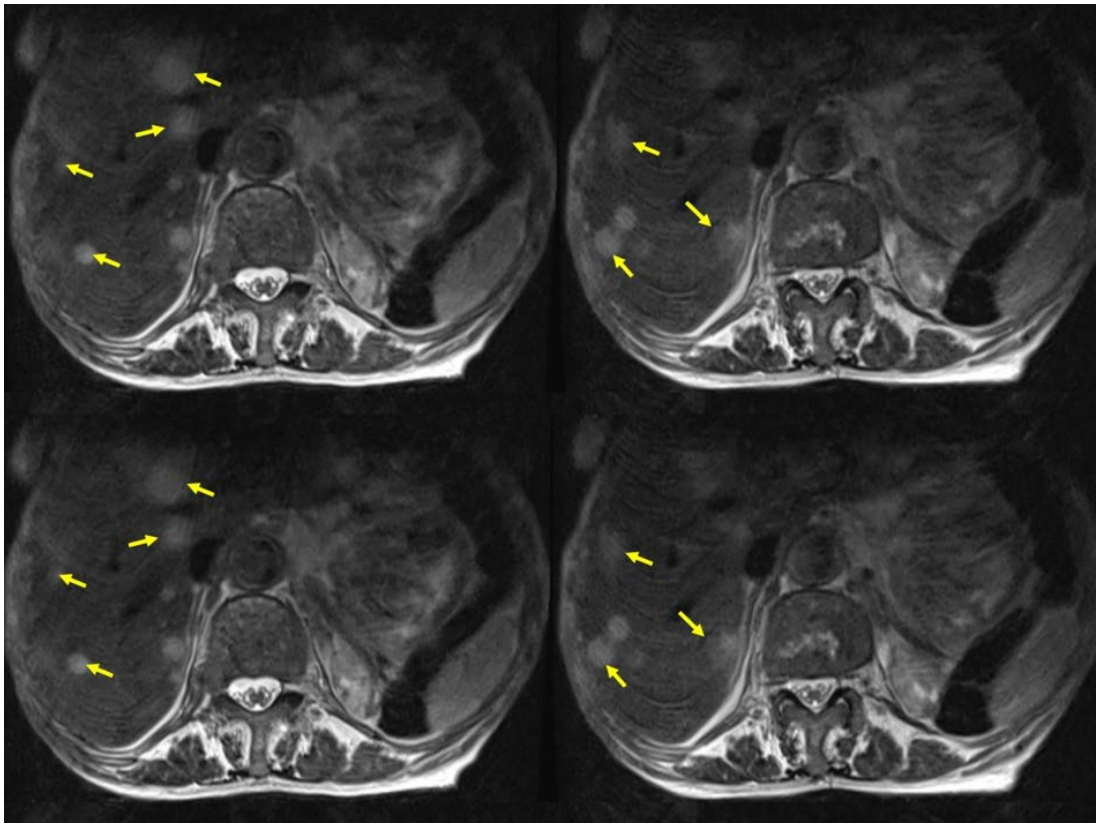

Figure 2. Lumbar spinal MR images of a 73-year-old female. Consecutive axial T2-weighted images of the patient revealed multiple hepatic masses (some of them were indicated with yellow arrows). Further medical investigations confirmed metastasis of lung cancer.

a reporting rate of 33.33%. For all patients with incidental findings on thoracic spinal MR images, the reporting rate was 8.33% and the best sequence and best plane to indicate these findings were T2-weighted (100%) and sagittal images (83.33%), respectively (Table 3) (Figure 5).

MR Images of the Cervical Spine

Incidental findings on cervical spinal MR images were detected for 56 patients [25 (44.64%) males and 31 (55.35%) females; mean age, 44.41 years; age range, 4-82 years]. The incidence rate for this examination was 29.16% (Table 1). Mucosal

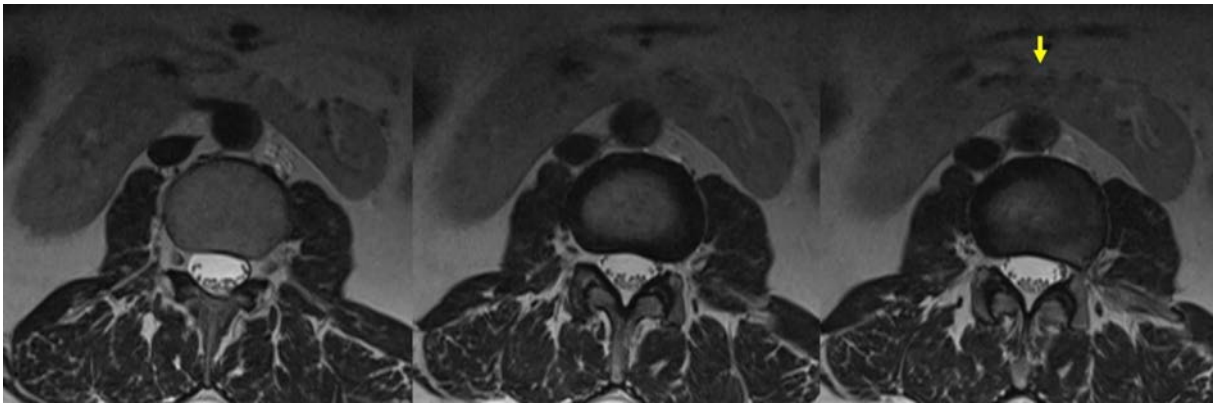

Figure 3. Consecutive T2-weighted images of lumbar spinal MR examination of 51-year-old male showing two kidneys with fusion of the lower poles (yellow arrow), consistent with horseshoe kidneys.

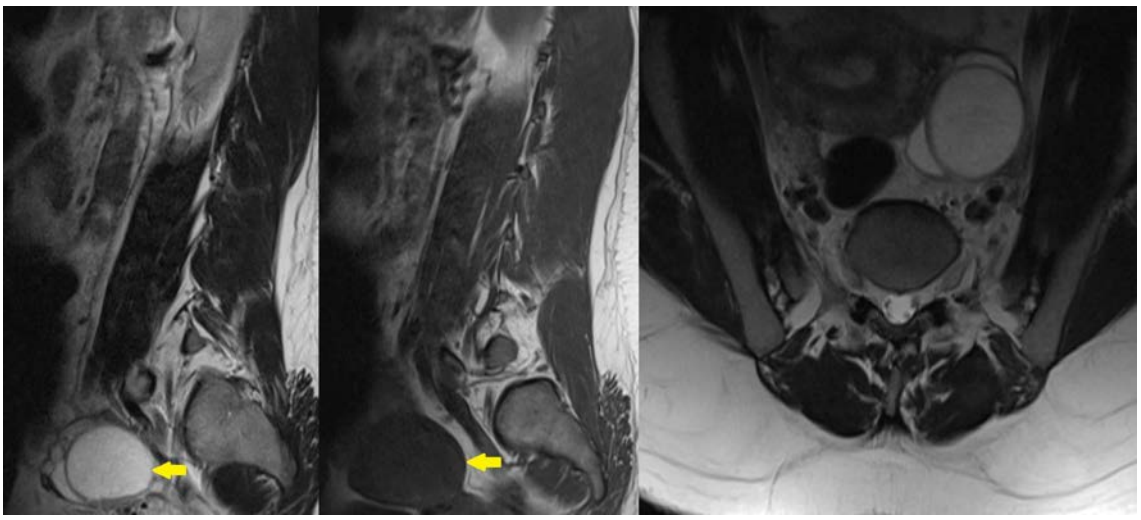

Figure 4. Sagittal T2-weighted, sagittal T1-weighted, and axial T2-weighted MR images of a 31-year-old female. Left ovarian cysts were noticed on images of the lumbar spine (yellow arrows)

thickening (34.42% of all incidental findings for this examination) was the most common incidental finding with a reporting rate of 14.28%. The overall the reporting rate was 29.5%, and the best sequence and the best plane to discriminate incidental findings on MR images of the cervical spine were the T2-weighted sequence (100%) and the sagittal view (93.44%), respectively. However, the axial plane was best suited to identify cervical lymphadenopathies (Table 4) (Figures 6 and 7).

Brain MRI

Incidental findings on brain MR images (n = 131) were identified in 131 patients [67 (51.14%) males and 64 (48.85%) females; mean age, 47.48 years; age range 6–93 years] demonstrating an incidence rate of 54.35% (Table 1). The paranasal sinuses were the most common site of the incidental findings. Mucosal thickening, retention cyst formation, and decreased pneumatization of mastoid air cells were the most common entities discerned asincidental findings. One patient with mucosal thickening of the nasopharynx, two with phthisis bulbi, one with scalp hematoma, one with a parotid lesion, and two with nasal septal deviation were noted with a reporting rate of 100%. Two instances of antrochoanal polyp formation were overlooked. T2-weighted images (98.13%) and axial planes (59.62%) were the best imaging approaches to

Table 3. Incidental extraspinal findings of thoracic spine MR imaging

Incidental finding	Related organ/system	Number (%)	Incidence Rate (%)	Reported	Unreported	Reporting rate (%)	Best sequence*	Best imaging plane*
Azygos lobe	Lung	1 (8.33)	3.22	0	1	0	T2 (1 of 1)	AX (1 of 1)
Decreased pneumatization	Lung	2 (16.66)	6.45	0	2	0	T2 (2 of 2)	AX (2 of 2)
Pleural effusion	Pleura	3 (25)	9.67	1	2	33.33	T2 (3 of 3)	AX (3 of 3)
Abdominal aorta aneurysm	Abdominal aorta	1 (8.33)	3.22	0	1	0	T2 (1 of 1)	AX (1 of 1)
Subcutaneous lipoma	Subcutaneous fat tissue	1 (8.33)	3.22	0	1	0	T2 (1 of 1)	SAG (1 of 1)
Paraaortic lymphadenopathy	Lymphatic system	1 (8.33)	3.22	0	1	0	T2 (1 of 1)	SAG (1 of 1)
Paravertebral soft tissue edema	Paravertebral soft tissue	1 (8.33)	3.22	0	1	0	T2 (1 of 1)	AX (1 of 1)
Hepatic mass	Liver	2 (16.66)	6.45	0	2	0	T2 (2 of 2)	AX (2 of 2)
TOTAL	**Lung and pleura# (50%)**	**12 (100)**	**32.25**	**1**	**11**	**8.33**	**T2# (100%)**	**AX# (83.33%)**

*Indicates the MR sequence and imaging plane that best depicts the incidental finding. Numbers in parenthesis (… of …) indicate the frequencies of certain incidental finding revealed by the best sequence or best plane among all MR sequences or planes. **#Indicates the organ/system, best sequence, or the best imaging plane which the incidental findings of lumbar spine MR imaging is mostly seen.**

Figure 5. Thoracic axial MR images of an 84-year-old female. Thrombosed abdominal aorta aneurysm (red arrows) and a hepatic cyst (yellow arrows) were detected incidentally on T2-weighted images.

Table 4. Incidental extraspinal findings of cervical spine MR imaging

Incidental finding	Related organ/system	Number (%)	Incidence Rate (%)	Reported	Unreported	Reporting rate (%)	Best sequence*	Best imaging plane*
Mucosal thickening	Nasopharynx	5 (8.19)	2.60	0	5	0	T2 (5 of 5)	SAG (5 of 5)
Thornwaldt cyst	Nasopharynx	2 (3.27)	1.04	1	1	50	T2 (2 of 2)	SAG (2 of 2)
Mucosal thickening	Paranasal sinuses	21 (34.42)	10.93	3	18	14.28	T2 (21 of 21)	SAG (21 of 21)
Retention cyst	Paranasal sinuses	14 (22.95)	7.29	6	8	42.85	T2 (14 of 14)	SAG (14 of 14)
Cervical lymphadenopathy	Lymphatic system	3 (4.91)	1.56	0	3	0	T2 (3 of 3)	AX (3 of 3)
Thyroglossal duct cyst	Thyroid	1 (1.63)	0.52	1	0	100	T2 (1 of 1)	SAG (1 of 1)
Thyroid hypertrophy	Thyroid	4 (6.55)	2.08	2	2	50	T2 (4 of 4)	SAG (4 of 4)
Thyroid nodule	Thyroid	11 (18.03)	6.72	5	6	45.45	T2 (11 of 11)	SAG (10 of 11)
TOTAL	**Paranasal sinuses# (34.42%)**	**61 (100)**	**29.16**	**18**	**43**	**29.50**	**T2# (100%)**	**SAG# (93.44%)**

*Indicates the MR sequence and imaging plane that best depicts the incidental finding. Numbers in parenthesis (… of …) indicate the frequencies of certain incidental finding revealed by the best sequence or best plane among all MR sequences or planes**. #Indicates the organ/system, best sequence, or the best imaging plane which the incidental findings of lumbar spine MR imaging is mostly seen.**

Table 5. Incidental extraneuronal findings on brain MR imaging.

Incidental finding	Related organ/system	Number (%)	Incidence Rate (%)	Reported	Unreported	Reporting rate (%)	Best sequence*	Best imaging plane*
Mucosal thickening	Paranasal sinuses	78 (48.44)	32.36	42	36	53.84	T2 (78 of 78)	AX (64 of 78)
Retention cyst	Paranasal sinuses	28 (17.39)	11.61	25	3	89.28	T2 (28 of 28)	COR/AX (14 of 28)
Decreased pneumatization	Mastoid cells	22 (13.66)	9.12	11	11	50	T2 (22 of 22)	COR (21 of 22)
Mucosal thickening	Nasopharynx	1 (0.62)	0.41	1	0	100	FL (1 of 1)	SAG (1 of 1)
Concha hypertrophy	Nasal cavity	10 (6.21)	4.14	4	6	40	T2 (10 of 10)	COR (9 of 10)
Antrochoanal polyp	Paranasal sinuses-nasopharynx	2 (1.24)	0.82	0	2	0	T2 (2 of 2)	AX (2 of 2)
Intraorbital hemorrhage	Orbit	3 (1.86)	1.24	2	1	66.66	T2 (2 of 3)	AX (3 of 3)
Phthisis bulbi	Orbit	2 (1.24)	0.82	2	0	100	T2 (2 of 2)	AX (2 of 2)
Intraocular lens (implants)	Orbit	8 (4.96)	3.31	3	5	37.50	T2 (8 of 8)	AX (8 of 8)
Scalp lesion	Scalp	3 (1.86)	1.24	2	1	66.66	T2 (3 of 3)	COR (2 of 3)
Scalp hematoma	Scalp	1 (0.62)	0.41	1	0	100	FL (1 of 1)	AX (1 of 1)
Parotid lesion	Parotid gland	1 (0.62)	0.41	1	0	100	T2 (1 of 1)	AX (1 of 1)
Septal deviation	Nasal septum	2 (1.24)	0.82	2	0	100	T2 (2 of 2)	COR/AX (1 of 2)
TOTAL	**Paranasal sinuses# (67.08%)**	**161 (100)**	**54.35**	**96**	**65**	**59.62**	**T2# (98.13%)**	**AX# (59.62%)**

*Indicates the MR sequence and imaging plane that best depicts the incidental finding. Numbers in parenthesis (… of …) indicate the frequencies of certain incidental finding revealed by the best sequence or best plane among all MR sequences or planes**. #Indicates the organ/system, best sequence, or the best imaging plane which the incidental findings of lumbar spine MR imaging is mostly seen.**

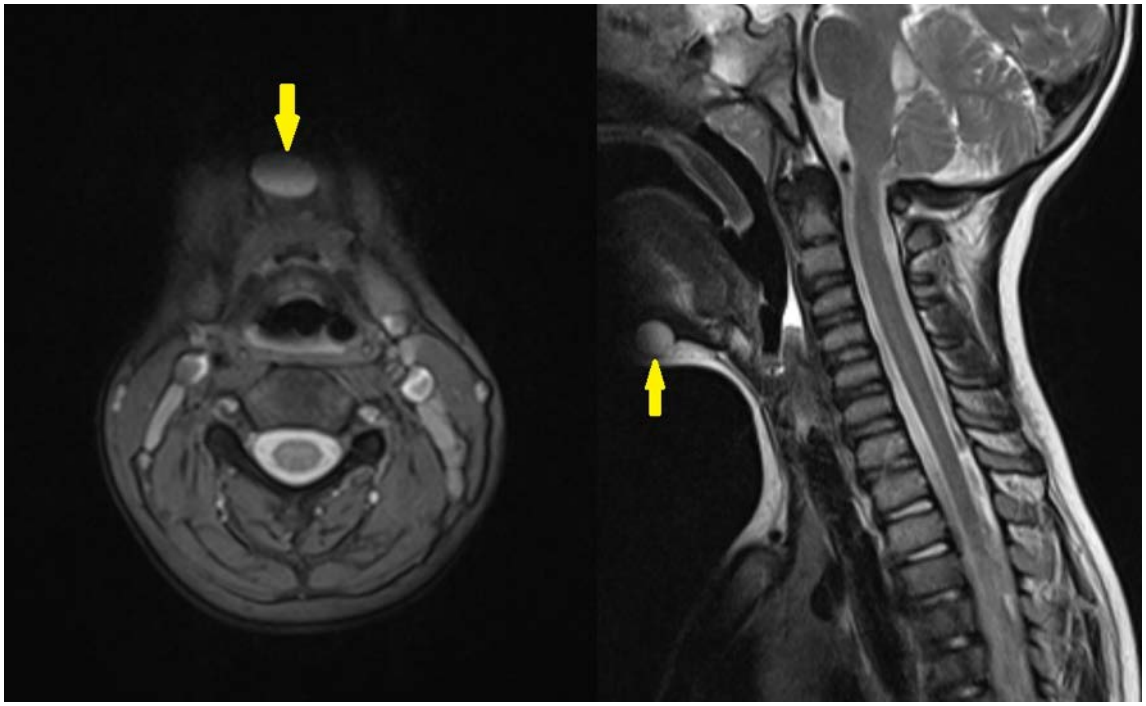

Figure 6. Axial and sagittal plane MR images of the cervical spine of a 4-year-old male revealed a hyperintense lesion with smooth contours (yellow arrows). Surgery confirmed that this lesion was consistent with a thyroglossal cyst.

discern incidental findings on brain MR images (Table 5) (Figure 8).

For all MRI examinations

Regarding 407 patients with incidental findings in this study [184 (45.20%) males and 223 (54.79%) females; mean age, 48.71 years; age range, 4-93 years], the incidence rate was 38.54% (Table 1) and the reporting rate was 39.91%. Overall, according to the interpreters, T2-weighted images were the best sequence (87.86%) and the axial view was the best plane (58.64%) to reveal the incidental findings.

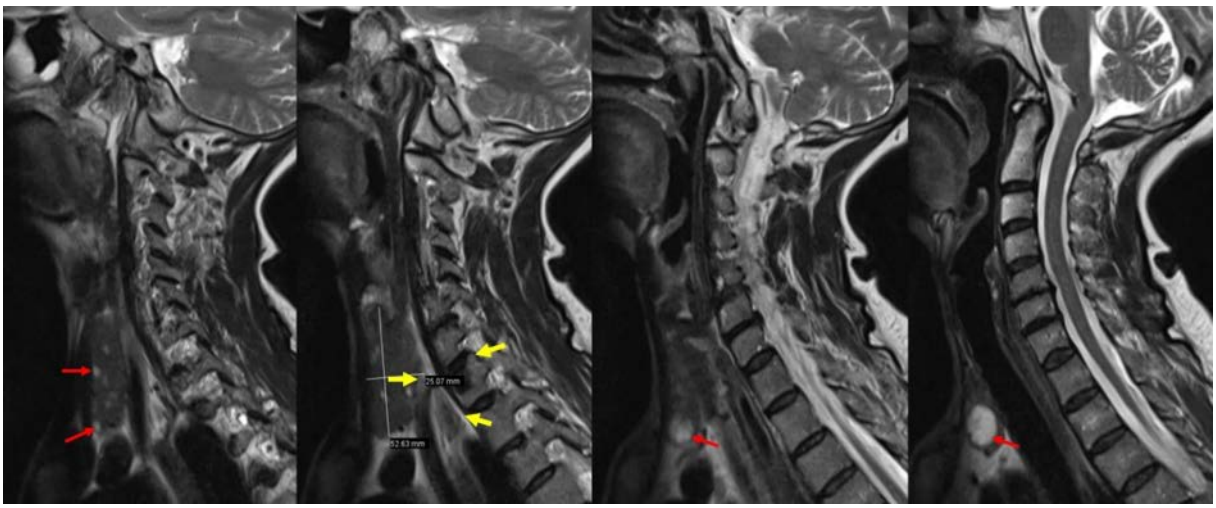

Figure 7. Consecutive sagittal T2-weighted MR images of a 65-year-old female. Thyroid hypertrophy (yellow arrows) and multiple nodule formations (some of them were indicated with red arrows

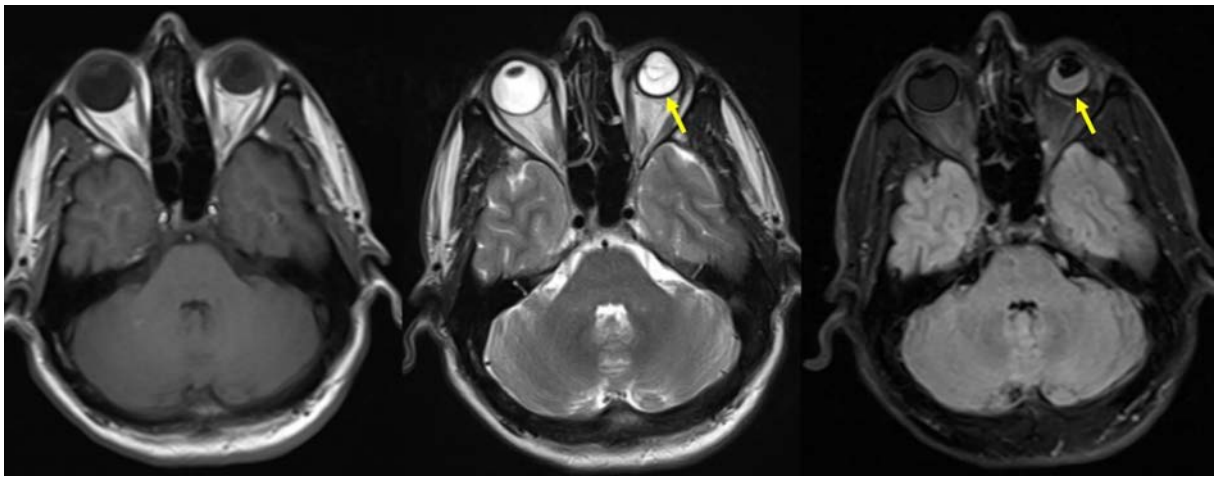

Figure 8. Axial T1-weighted, T2-weighted and FLAIR sequences of the brain MR images of a 36-year-old male. The left ocular bulbus (yellow arrow) was smaller than the normal right eye with signal alterations possibly indicating intraocular hemorrhage. Patient's file confirmed that a history of trauma to the left eye before the examination. No further information about the orbit was provided by the clinician.

DISCUSSION

In this study, the highest rate of incidental findings occurred with brain MR images, the lowest reporting rate was observed for images of the thoracic spine, the T2-weighted sequence was the best imaging sequence, and the axial plane was the most useful imaging plane to identify incidental findings with regard to percentage.

An abundance of data can be derived from MR images about the region of interest, besides the focusing point and parameters, which is a very important aspect of interpretation of MR images for the radiologist. An incidental lesion might be an explanatory cause of the major problem of the patient or could be the first obvious manifestation or a proof of an important disease that is otherwise non-symptomatic.

The medicolegal aspects of incidental lesions are of great importance to the radiologist. Magnavita *et al*. [1] and Fileni *et al*. [2] noted that diagnostic error is often the basis of lawsuitsagainst radiologists. Moreover, the authors previously reported possible causes of perception errors resulting in the failure to detect an abnormality on a radiological examination.

In a retrospective review of 1517 lumbar CT examinations conducted in 1986, Frager *et al*. [3] reported that extra spinal pathologies were overlooked in 22 (1.45%) cases with uterine leiomyoma and abdominal aorta aneurysm being the most common incidental lesions. Lee *et al*. [4] reported an incidence rate of extra spinal findings among 400 lumbar spine CT examinations of 40.5% with the gastrointestinal system (71 patients) and genitourinary system (50 patients) being the most common systems with incidental lesions. Park *et al*. [5] evaluated the frequency and types of incidental findings on MR images of the lumbar spine and reported incidental findings in 107 (8.4%) of 1268 patients.

In the present study, the incidence rates as well as the reporting rates were evaluated. Tuncel *et al*. [6] reinterpreted 1278 lumbar MR images and described incidental findings in 253 cases with a reporting rate of overall incidental findings of 28%, which was in accordance with the reporting rate of 31.74% in the present study. Similar to this study, the kidney was the most common location (37.15%) and renal cysts were the most common incidentally discovered lesions. Myoma was the most common uterine incidental lesion (15.81%) as well as in our study. A study by Tuncel *et al*. [6] reported incidental findings of retroaortic renal vein variations in 52 (20.5%) of 253 patients with an incidence rate of 4%. In the present study, anatomic variances occurred as incidental findings in 24 patients with an incidence rate of 4.05%, nearly the same as that reported previously.
The main purpose of thoracic spinal MR imaging is to evaluate the intervertebral discs and spine, as well the large thoracic space around the region of interest to enable observation of the intrathoracic area, especially

the lungs and pleura. Respiratory and cardiovascular motions cause low spatial resolution and a low signal to noise ratio of the lung parenchyma, thus spinal MR imaging is not sufficient to characterize a lung lesion. However, the signal loss due to thepresence of air in the lungs also creates contrast; therefore, MR images may be suitable to reveal prominent lesions. Even a huge space occupied by lesions or large areas of air loss can be overlooked during spinal evaluations if the radiologist solely focuses on the main parameters of thoracic spinal MR imaging. Kamath *et al*. [7] reported that solitary pulmonary nodules, pleural effusions, interstitial fibrosis of the lungs, and pneumonia were frequent incidental findings on thoracic images. In the present study, the lungs and pleura were the most common sites of incidental findings while the most common finding was pleural effusion.

Most similar studies on incidental findings in cervical imaging methods have focused on thyroid nodules. For example, Grady *et al*. [8] reported a highly variable size of thyroid nodules ranging from 10 to 19 mm in diameter, and only 73% of patients with incidental thyroid nodules of ≥ 20 mm in diameter were mentioned in the "Impression" section of the radiology report. In a retrospective study of 61 patients who underwent both spinal MRI and thyroid ultrasonography, Cho *et al*. [9] reported that very few thyroid nodules less than 1 cm in size and only one-third of those larger than 1 cm were detected by MRI, thus the authors recommended sonography for detection of thyroid nodules that are not readily recognized on MR images. Mancuso [10] commented that "the younger the patient, the higher the risk of malignancy" in regards to an individual thyroid nodule and suggested baseline ultrasonography to evaluate incidental nodules. Kamath *et al*. [7] reported meningioma, thyroid and salivary gland lesions, and nasopharyngeal tumors as the most frequent incidental findings encountered during cervical spinal MRI evaluation. In the present study, the paranasal sinuses were the most common site of incidental findings with an incidence rate of 10.93%, whereas the incidence rate of thyroid nodules was 5.72% with no instance of a meningioma or nasopharyngeal tumor as an incidental lesion.

Katzman *et al*. [11] studied brain MRI scans of 1000 volunteers who participated as control subjects for various research protocols and found that 18% of all volunteers had incidental abnormal findings, which included 132 volunteers with sinusitis; this was the most common incidental finding. In a study of images of 2000 people from a population based on the Rotterdam Study, Vernooij *et al*. [12] reported that the most frequent finding was brain infarct, followed by cerebral aneurysm and benign primary tumors. A systematic review and meta-analysis of 16 studies of incidental findings of brain MRI of 19559 patients conducted by Morris *et al*. [13] in 2009 reported that the crude prevalence of incidental findings on brain MRI was 2.7%, or in other words, one incidental finding for every 37 neurologically asymptomatic subjects scanned. The prevalence of incidental neoplastic brain findings was 0.70% in a meta-analysis of 16 studies and 2.0% (range, 1.1%-3.1%)in a review of 15 studies that excluded white matter hyperintensities, silent infarcts, and microbleeds. In the present study, besides the most common lesions of mucosal thickening, retention cysts of the paranasal sinuses, and decreased pneumatization of mastoid cells, other lesions of the scalp, parotid gland, and orbitwere also observed.

To the best of our knowledge, there is limited information in the literature regarding optimal sequences and plains to reveal incidental findings on MR images. In this study, the T2-weighted sequence was the most useful for all examination types while the axial plain was best for the lumbar and thoracic spine as well as the brain. Moreover, the sagittal plain was best for MR imaging of the cervical spine to reveal incidental findings.

As an alternative aspect to this discussion, other reports have implied that reporting incidental findings may not always be beneficial to the patient. For example, Westbrook *et al*. [14] claimed that, although incidental lesions are indeed serendipitous and subsequent treatment reduces morbidity and mortality, a number of patients may undergo extensive diagnostic examinationswhich may lead to no improvement in health. The authors agree that some patients are in fact harmed by such examinations because of various reasons, such as cumulative radiation exposure resulting from serial scans, as well as unnecessary anxiety and distress.

Limitations

Although it is a rather difficult and subjective approach to determine the best sequence and imaging plain for this purpose, the aim of this study was to ascertain the importance of specific imaging sequences and the best planes for the evaluation process, especially to avoid underestimation or overlooking of the so-called "incidental" findings. Even though interpretations were made by the consensus of at least two experienced radiologists, this situation may have been a limitation to this study. The FOV for the specific areas of each MRI examination might have limited the exact visualization of other incidental findings. The interpreters were not able to identify some vague MRI signals in the marginal parts of the frames or the first or last cross-sectional views, which may represent the edge of another incidental finding or an artifact of no significance. Only the MRI signals that clearly and undoubtedly indicated the lesion, anomaly, or anatomical variance were accepted as an incidental finding by the reviewers, which may have been another limitation to the detection of incidental findings. Moreover, although the MR images were evaluated by three experienced radiologists, human errors may have occurred, thus the results may not perfectly represent the rates of incidental findings. Lastly, some important parameters (such as reporting rates, best plane, and sequence.) were statistically compared for each MRI examination, but the total number of patients who underwent thoracic spinal MRI was not sufficient for comparisons.

CONCLUSION

In conclusion, incidental findings are commonly detected during routine spinal and brain MRI interpretations. However, these findings may not have clinical importance and are occasionally omitted from formal radiological reports in daily practice. We strongly recommend checking the T2-weighted axial plane for MR imaging of the lumbar, thoracic, and cervical spine, and brain, and taking a second look at the T2-weighted sagittal plane MR images of the cervical spine during radiological evaluations.

Author Contributions

Guarantor of integrity of entire study: VK; Study concepts: VK, UM; Study design: VK, HA, ÜCÖ, SSK;Data acquisition: VK, ÜCÖ; Data analysis: VK, ÜCÖ, AKS, HA; Interpretation: VK, ÜCÖ, SSK; Literature research: VK, AKS, HA; Manuscript drafting: VK, UM, AKS, HA; Manuscript editing: VK, UM, ÜCÖ, SSK, AKS, HA, AE.

Ethics

This study has been approved by ethics committee.

Conflict of interest

The authors disclosed no conflict of interest during the preparation or publication of this manuscript.

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REFERENCES

[1] Magnavita N, Magnavita G, Fileni A, Bergamaschi A. Ethical problems in radiology: medical error and disclosure. Radiol Med 2009;114:1345-55.

[2] Fileni A, Magnavita N. A 12-year follow-up study of malpractice claims against radiologists in Italy. Radiol Med 2006;111:1009-22.

[3] Frager DH, Elkin CM, Kansler F, Mendelsohn SL, Leeds NE. Extraspinal abnormalities identified on lumbar spine CT. Neuroradiology 1986;28:58-60.

[4] Lee SY, Landis MS, Ross IG, Goela A, Leung AE. Extraspinal findings at lumbar spine CT examinations: prevalence and clinical importance. Radiology 2012;263:502-9.

[5] Park HJ, Jeon YH, Rho MH, Lee EJ, Park NH, Park SI, et al. Incidental findings of the lumbar spine at MRI during herniated intervertebral disk disease evaluation. Am J Roentgenol 2011;196:1151-5.

[6] Tuncel SA, Çağlı B, Tekataş A, Kırıcı MY, Ünlü E, Gençhellaç H. Extraspinal incidental findings on routine MRI of lumbar spine: prevalence and reporting rates in 1278 patients. Korean J Radiol 2015;16:866-73.

[7] Kamath S, Jain N, Goyal N, Mansour R, Mukherjee K. Incidental findings on MRI of the spine. Clin Radiol

2009;64:353-61.
[8] Grady AT, Sosa JA, Tanpitukpongse TP, Choudhury KR, Gupta RT, Hoang JK. Radiology reports for incidental thyroid nodules on CT and MRI: high variability across subspecialties. Am J Neuroradiol 2015;36:397-402.
[9] Cho HW, Park JO, Lee YH, Chung SY, Suh JS. Should we recommend ultrasonography for an incidental thyroid nodule on additional cervicothoracic sagittal T2-weighted image of lumbar spine MRI? Investig Magn Reson Imaging 2015;19:224-30.
[10] Mancuso AA. Another pesky incidental thyroid nodule! Am J Neuroradiol 2005;26:2444-5.
[11] Katzman GI, Dagher AP, Patronas NJ. Incidental findings on brain magnetic resonance imaging from 1000 asymptomatic volunteers. JAMA 1999;282:36-9.
[12] Vernooij MW, Ikram MA, Tanghe HL, Vincent AJPE, Hofman A, Krestin GP, et al. Incidental findings on brain MRI in the general population. New Engl J Med 2007;357:1821-8.
[13] Morris Z, Whiteley WN, Longstreth WT Jr, Weber F, Lee YC, Tsushima Y, et al. Incidental findings on brain magnetic resonance imaging: systematic review and meta-analysis. BMJ 2009;339:b3016.
[14] Westbrook JI, Braithwaite J, McIntosh JH. The outcomes for patients with incidental lesions: serendipitous or iatrogenic? Am J Roentgenol 1998;171:1193-6.