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The diagnostic value of abbreviated MRI protocol in the surveillance of Branch-Duct intraductal papillary mucinous neoplasm

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ABSTRACT

Purpose: To assess the diagnostic value of abbreviated protocol (AP) MRI to detect the degeneration signs in branch-duct intraductal papillary mucinous neoplasms (BD-IPMNs) in patients undergoing a routine MRI follow-up.

Methods: This dual-center retrospective study include patients with BD-IPMN diagnosed on initial comprehensive protocol (CP) MRI who underwent routine MRI follow-up. CP included axial and coronal T2-weighted images (T2WI), axial T1-weighted images (T1WI) before and after contrast administration, 3D MR cholangiopancreatography (MRCP) and diffusion-weighted images (DWI). Two APs, eliminating dynamic sequences ± DWI, were extracted from CP. Two radiologists evaluated the APs separately for IPMN degeneration signs according to Fukuoka criteria and compared the results to the follow-up CP. In patients who underwent EUS, imaging findings were correlated with pathological results. Per-patient and per-lesion sensitivity, specificity, PPV, NPV, and accuracy of APs were calculated. Additionally, the acquisition time for different protocols was calculated.

Results: One hundred-fourteen patients (56.1 % women, median age: 71 years) with 256 lesions were included. Degeneration signs were observed in 24.6 % and 12.1 % per-patient and per-lesion, respectively. Regarding APs, the per patient sensitivity, specificity, PPV, NPV, and accuracy in the detection of the degeneration signs were 100 %, 93.5 %, 83.3 %, 100 %, and 95.1 %, respectively. No additional role for DWI was detected. AP without DWI economized nearly half of CP acquisition time (388 versus 663 s, respectively).

Conclusion: AP can confidently replace CP for BD-IPMN follow-up with high sensitivity and PPV while offering benefits such as patient comfort, improved MRI accessibility, and reduced dedicated time for image analysis. DWI necessitates special consideration.

Clinical Relevance Statement: Our data suggest that APs safely detect all degeneration signs of IPMN. While there is an overestimation of mural nodules due to the lack of contrast injection, this occurs in a negligible number of patients.

1. Introduction

Pancreatic cystic lesions are increasingly diagnosed in routine radiological practice, due to improved diagnostic imaging availability and developing imaging techniques that offer higher resolution. Incidental detection rates with Magnetic Resonance Imaging (MRI) and Computed Tomography (CT) in patients without a pancreatic disease history are reported at 13.5 % and 2.6 %, respectively [1]. In one of the largest study based on pancreatic surgical resection, intraductal papillary mucinous neoplasm (IPMN) was the most frequently encountered lesion with a prevalence of 38 %, followed by mucinous cystic neoplasms (MCN) and serous cystic neoplasm, observed in 23 % and 16 % of

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resections, respectively [2]. Among various pancreatic cystic lesions, mucin-producing pancreatic cystic lesions, encompassing IPMNs and MCNs, are known to be associated with a risk of malignant degeneration, necessitating routine clinical and imaging follow-up. Based on a systemic review and *meta*-analysis, 3.7 % of patients with branch-duct IPMNs will eventually develop pancreatic malignancy, while MCNs measuring less than 4 cm are associated with invasive carcinoma in only 0.03 % of cases [3,4].

During the last decades, various guidelines and recommendations for managing IPMN have emerged, differing in follow-up duration. For instance, the American Gastroenterological Association suggests follow-up for up to 5 years, while the European guidelines recommend lifelong surveillance until potential surgery [5,6]. Despite these discrepancies, all guidelines are unanimous for the eventual degeneration risk of IPMN mandating close observation. Although there are discordances between these guidelines, the imaging features that should be assessed during follow-up are likely similar. These features include lesion size, cyst growth, presence of mural nodule, and increased main pancreatic duct diameter [5–9].

While no consensus has been reached on the timing and type of imaging modality for IPMN follow-up, MRI has gained popularity for its superior contrast resolution and absence of ionizing radiation, particularly in this patient population requiring regular imaging surveillance. However, the prolonged acquisition time of MRI, notably problematic in elderly and claustrophobic patients, is not negligible. MRI comprehensive protocol (CP) includes morphological, functional and contrast enhanced sequences which combination of them leads to a scanning time that can last up to 35 min [10,11]. Furthermore, in clinical practice, the additional time for venous cannulation and power injector preparation should also be considered. While the aforementioned imaging features are usually readily observed by T2-weighted images (T2WI), the necessity of contrast medium administration and diffusion weighted imaging (DWI) is debated, leading to a proposed abbreviated protocol (AP) eliminating the dynamic sequences ± DWI [12]. Few studies evaluated the efficacy of AP in this group of patients, reporting different combination of AP that may replace the CP [10,13,14]. However, evidences are still limited in order to support the advantage of the AP for the clinical management of patients with IPMN.

This study aims to assess the clinical feasibility of AP to be adopted in routine radiological surveillance in patients with branch-duct intraductal papillary mucinous neoplasms (BD-IPMNs) and determine if it can confidentially replace CP without overlooking MRI features indicative of malignant degeneration. Additionally, the study aims to evaluate the role of DWI within this context.

2. Materials and Methods

The institutional ethic committee has approved this retrospective bicentric study and inform consent was obtained.

2.1. Patient selection

All consecutive patients with known BD-IPMN who underwent an abdominal MRI follow-up examination between January 2018 and December 2020 at two tertiary hospitals were recruited based on the PACS archive of both centres. The diagnosis of BD-IPMN was made based on the initial MRI, corresponding to cystic lesions with evident communication with the pancreatic duct. Included patients had a baseline pancreatic MRI and at least one follow-up with CP, with a minimum interval of six months. The most recent MRI was selected for analysis in cases where multiple MRIs were available. Patients with follow-up MRI lacking contrast media injection, a history of pancreatic resection, altered image quality due to motion or metallic artefacts, evidence of degeneration in IPMNs on the initial MRI, and patients with conditions other than IPMN during follow-up were further excluded.

Demographic information was extracted from medical records, including results from endoscopic ultrasound (EUS) when available. The included EUSs were performed within 3-months intervals from the follow-up MRIs. Immunohistopathologic analyses were collected when accessible.

2.2. Protocols definition

Baseline and follow-up MRIs were randomly performed on 1.5 and 3 T machines at each centre. Four different MR scanners were used: Siemens Aera Magnetom 1.5 T (Erlangen, Germany), Siemens Prisma Magnetom 3 T (Erlangen, Germany), Philipps Ingenia 1.5 T (Best, Netherlands), GE Discovery MR750 3 T (Chicago, USA). The contrast media included Gadoteridol (Prohance, Bracco, Massy, France) and Gadoteric acid (Dotarem, Guerbet, Villepinte, France). MRI comprehensive protocol (CP) included axial and coronal T2-weighted images (T2WI), axial fat-saturated T1-weighted images (T1WI) before and after contrast administration, 3D MR cholangiopancreatography (MRCP) and diffusion-weighted images (DWI). Detailed protocols are outlined in **Table 1S**.

The APs of follow-up examinations were extracted from follow-up CP, as every included patient underwent at least one follow-up MRI with CP. AP extracted from CP consisted of axial and coronal T2WI, 3D MRCP, and DWI (AP with DWI). To assess the role of DWI, a second AP, consisting only of axial and coronal T2WI, 3D MRCP, was created (AP without DWI).

2.3. Image analysis

Two radiologists (SM and LW), with six years of experience each in abdominal radiology independently assessed MRIs from their respective centres. While aware of the study's objective, they remained blinded to IPMN EUS or pathology results.

Prior to image analysis, a comprehensive quality assurance process was implemented. The two radiologists meticulously reviewed together a set of 30 cases involving MRIs with BD-IPMN. This joint assessment aimed to establish a consensus on the evaluation criteria and ensure a unified approach to the interpretation of the imaging data.

All BD-IPMNs measuring $\geq$ 5 mm were assessed. The evaluation of IPMN degeneration was conducted in accordance with the most recent iteration of the Fukuoka guidelines (2017) [8]. Based on these guidelines, the signs of cyst degeneration are divided into high-risk stigmata and worrisome features. In the present study, we combined these features for image analysis, as the presence of any one of them indicates varying degrees of degeneration necessitating further evaluation. These criteria encompass the lesion size $\geq$ 3 cm, increased cyst size ($\geq$5mm during 2 years), enhancing mural nodule, thickened cyst wall, main pancreatic duct dilatation ($\geq$5mm), and abrupt change in pancreatic duct calibre with distal atrophy. Notably, in APs, all mural nodules were noted for subsequent evaluation with contrast media administration.

During a first step, all baseline MRIs were reviewed by a radiologist to confirm the diagnosis of branch-duct IPMN and to exclude the presence of signs indicating cystic degeneration. During a second step, the most recent follow-up MRI CP was assessed and compared to the baseline MRI to identify any newly appeared degeneration signs. The lesion location, size change, presence of enhancing mural nodule, thickened cyst wall, and main pancreatic duct dilatation were assessed. In a third step, after a 4-week interval to minimize recall bias, the AP with DWI extracted from the most recent follow-up MRIs were reviewed in a similar manner to CP MRIs. Finally, in a fourth step, a review was conducted 4 weeks later, focusing on AP without DWI extracted from most recent follow-up MRIs, using the same methodology as employed in the previous two reviews. The interval between reviews was chosen to minimize potential biases and ensure rigorous analysis. The acquisition time of the different sequences were recorded on four MRI scanners, and the mean time for each sequence was considered as the representative value.

2.4. Statistical analysis

Categorical variables were reported as numbers and percentages. Continuous variables are provided with median and interquartile ranges (IQR) after testing the normality distribution with the Shapiro-Wilk test. Considering CP as reference standard, per-patient and per-lesion sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and accuracy of APs were calculated with binominal 95 % confidence intervals.

Statistical analyses were conducted by using the SPSS Software (v26.0. IBM, Armonk, NY, USA).

3. Results

3.1. Patient Characteristics

From an initially retrieved pool of 126 patients, 12 were excluded, leaving a final cohort of 114 individuals (Fig. 1). The patient cohort consisted of 59 individuals from centre one and 55 individuals from centre two, representing 51.7 % (59/114) and 48.2 % (55/114), respectively. Among them, 56.1 % were women (64/114), and the age ranged from 27 to 83 years (median age: 71 years). Within this cohort, a total of 256 IPMNs were detected, with lesion sizes ranging from 5 to 56 mm (median size 10 mm, IQR 7, 16 mm). Overall, 48.2 % (55/114) of patients had a single lesion, while 16.7 % (19/114) of patients had more than three lesions, with the average number of lesions per-patient being 2.2 ± 1.7. Lesions were predominantly located in the tail of the pancreas (25 %, 64/256), followed by the body (23.8 %, 61/256). Cohort characteristics are provided in Table 1.

Table 1
Characteristics of the final cohort.

Characteristics (114 patients, 256 lesions)	Number (%)
Age (years)[a]	71 (65, 76)
Sex	
Males	50 (43.9)
Females	64 (56.1)
Number of lesions per patient	
1	55 (48.2)
2–3	40 (35.1)
>3	19 (16.7)
Size (mm)[a]	10 (7, 16)
Location of the lesions	
Head	52 (20.3)
Uncinate	40 (15.6)
Isthmus	39 (15.2)
Body	61 (23.8)
Tail	64 (25.0)
Interval time between MRIs (days)[a]	794 (362, 1193)

[a] Continuous variables are reported as medians and interquartile ranges in parenthesis.

3.2. Analysis based on CP on a patient level

Among the 114 patients, 6 % (7/114) of patients exhibited an initial lesion size of 30 mm or greater. Changes in lesion size were noted in 40.4 % (46/114) of patients, with 27.2 % (31/114) showing an increase. Based on Fukuoka criteria, 20.2 % (23/114) were considered to have significant lesion growth. IPMN with wall thickening or main duct dilatation with parenchyma atrophy were both found in 2.6 % (3/114) of patients. The occurrence of two and four degeneration signs was noted in 1.8 % (2/114) and 0.9 % (1/114) of patients, respectively. Two demonstrative cases are illustrated in Fig. 2 **and** Fig. 3.

3.3. Analysis based on CP on a lesion level

In the examination of 256 IPMNs, 3.1 % (8/256) were $\geq$ 30 mm. Size changes were evident in 22.7 % (58/256) of lesions, with 14.8 % (38/256) experiencing an increase. Among them, 10.2 % (26/256) exhibited a significant size increase. 1.2 % (3/256) of lesions presented wall thickening, and the same proportion of 1.2 % (3/256) had main pancreatic duct dilatation with pancreatic parenchyma atrophy. 0.8 % (2/256) of lesions showed two degeneration signs while four degeneration signs were detected in 0.4 % (1/256) of lesions. Analyses at patient and lesion levels are outlined in Table 2.

3.4. Comparison of CP and APs for detecting degeneration signs

No difference was observed between the two APs in detecting IPMN degeneration signs according to Fukuoka criteria. Regarding significant size change, thickened cyst wall and main pancreatic duct dilatation with parenchymal atrophy, no difference was detected between CP and APs (Table 3). A comparative analysis of CP and APs revealed degeneration signs in 24.6 % (28/114) and 29.8 % (34/114) of patients in CP and APs, respectively. These differences are only related to the difference on mural nodule detection, as CP and APs showed the same results for other signs. CP identified enhancing mural nodule in 3.5 % (4/114), whereas rate of patients with mural nodule detected on APs was 11.4 % (13/114). The nine nodules without enhancement on CP were distributed as follows: three were observed in patients who already exhibited other degeneration signs, while the remaining six were found in lesions among patients without any additional degeneration sign indications (shaded areas in Fig. 4). On a lesion level, the degeneration signs were found in 12.1 % (31/256) in CP compared to 14.8 % (38/256) in APs. The distribution of degeneration signs with CP and APs on both patient and lesion levels are detailed in Fig. 4.

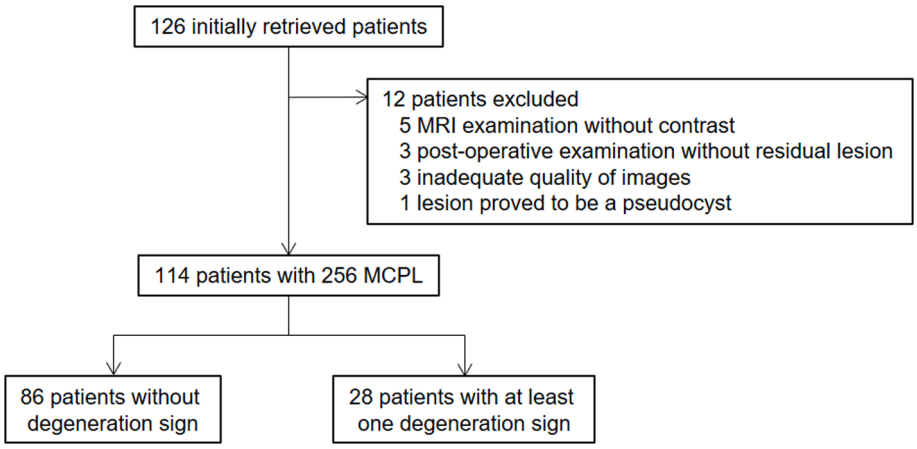

Fig. 1. Study workflow.

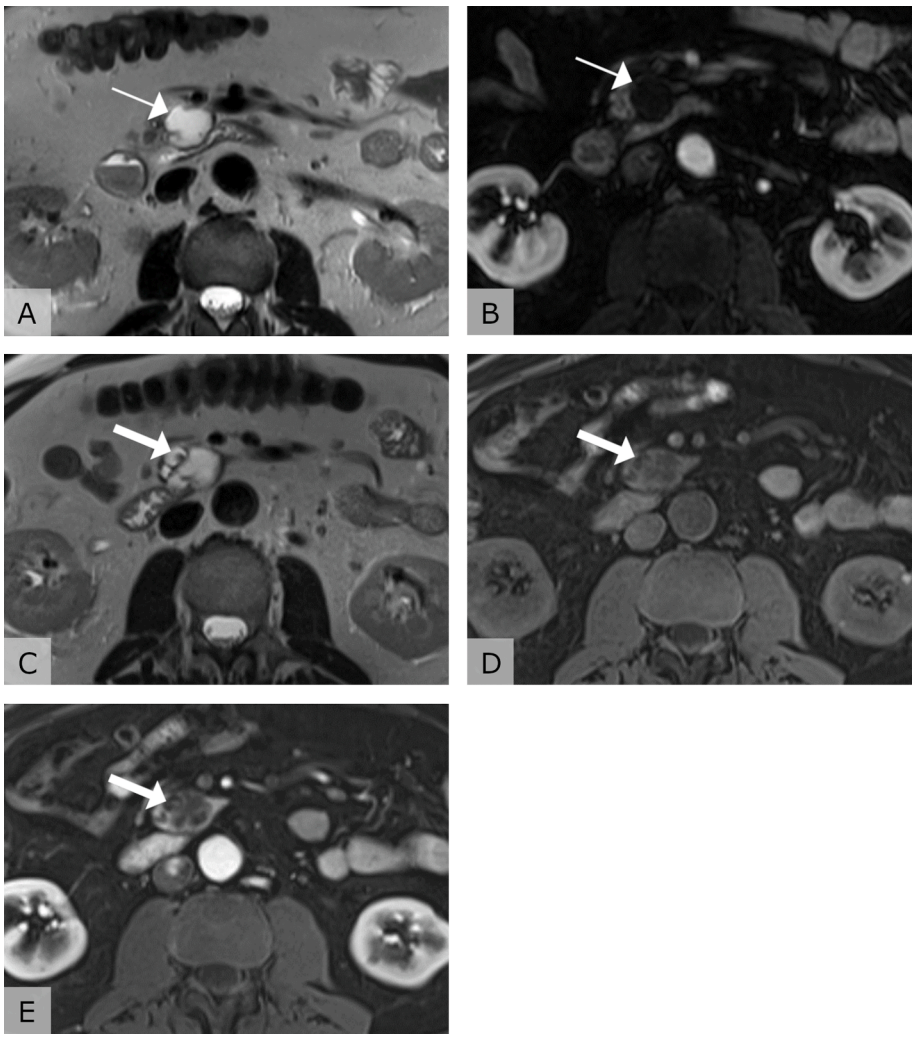

Fig. 2. A 68-year-old woman with intraductal papillary mucinous neoplasm (IPMN) with high-grade dysplasia. (A) Baseline T2WI shows a 27 mm branch-duct IPMN situated in the pancreatic head, with some internal septa without mural nodule (thin arrow). (B) Contrast-enhanced T1WI shows no internal enhancement (thin arrow). (C) Follow-up MRI 2 years later demonstrates the appearance of an internal nodule of 3 mm (thick arrow). Unenhanced T1WI (D) and contrast-enhanced T1WI (E) show a contrast uptake of the nodule (thick arrows).

3.5. Diagnostic performance of APs

For APs, the per-patient sensitivity, specificity, PPV, NPV and accuracy for the detection of degenerations signs were 100 %, 93.5 %, 83.3 %, 100 % and 95.1 %, respectively. The same values for per-lesion analysis were 100 %, 97 %, 82 %, 100 % and 97.4 %, respectively (Table 4).

3.6. MRI and EUS correlation

All patients with an initial lesion size of $\geq$ 30 mm underwent primary EUS, revealing low-grade dysplasia in all lesions. Out of twenty-eight EUS and FNA $\pm$ biopsy indications made for the presence of degeneration signs on follow-up exams, twenty-two EUSs were performed. For patients exhibiting only a significant increase in size, EUS performed in 14 patients demonstrated low-grade dysplasia in all cases. Among three patients with only a mural nodule as degeneration sign, EUS showed low-grade dysplasia in two patients, while the remaining patient demonstrated high-grade dysplasia. EUS performed in patients with wall thickening or main duct dilatation as the sole features of degeneration both revealed low-grade dysplasia. In the case of three patients with more than one degeneration sign, EUS showed no high-grade dysplasia or invasive carcinoma. Notably, only one EUS showed high-grade dysplasia in the whole cohort. This patient subsequently underwent surgical resection, which confirmed the diagnosis of high-grade dysplasia. Details are shown in Fig. 5.

3.7. Sequence acquisition time

The mean acquisition time for T2WI coronal, T2WI axial, DWI, T1WI before and after contrast administration including dynamic sequences and 3D MRCP were 77 s, 109 s, 204 s, 71 s, and 202 s, respectively. Mean acquisition time for CP, AP with DWI, and AP without DWI is 663, 592, and 388 s, respectively. Omitting the T1WI sequences could save more than 1 min while deleting also the DWI sequence could lead to a time-saving of up to 4 min in the total acquisition time.

4. Discussion

The findings of this study demonstrate that the AP protocol can safely replace the traditional CP without compromising diagnostic performance and or affecting clinical decision-making. It is noteworthy that implementing the AP requires only a negligible number of patients to be recalled to undergo the CP, overcoming the need for routine CP follow-up for all patients with IPMN. The adoption of the AP not only significantly reduces the healthcare cost burden but it can also alleviate patient

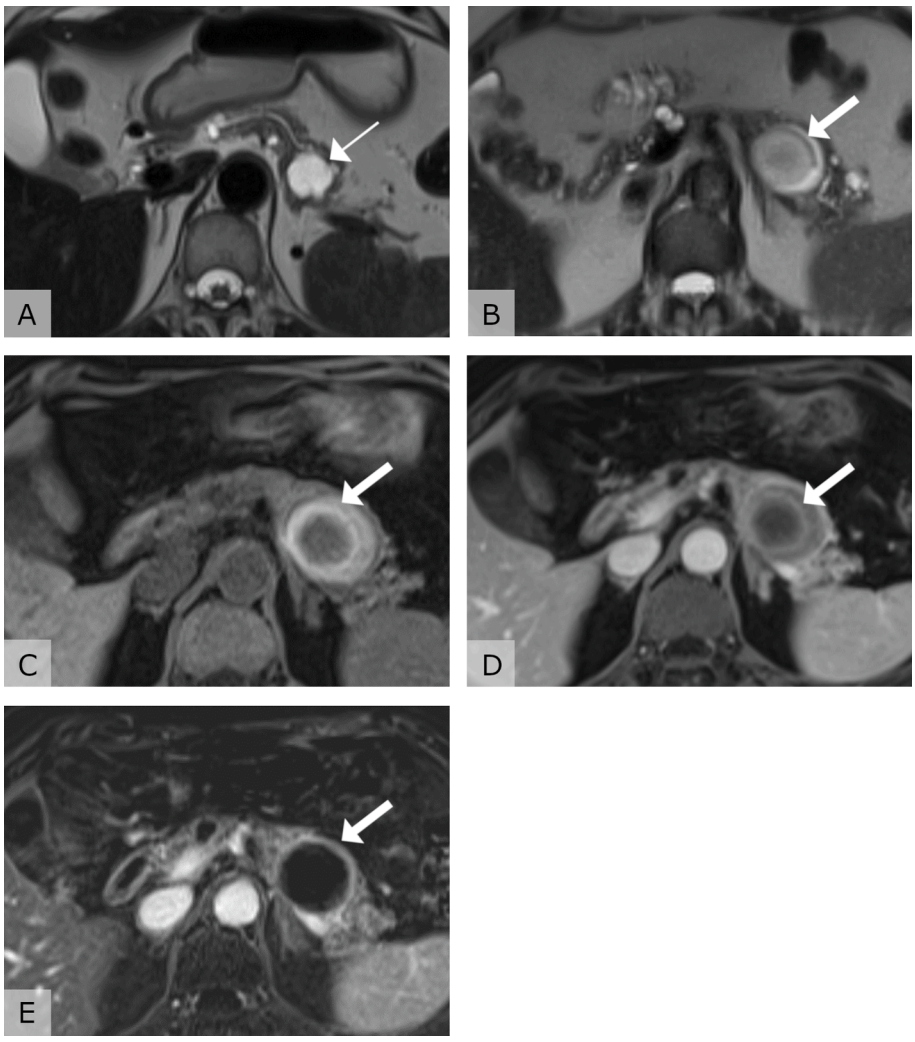

Fig. 3. A 55-year-old woman with intraductal papillary mucinous neoplasm (IPMN) with low-grade dysplasia. (A) Baseline T2WI shows a 21 mm branch-duct IPMN situated in the pancreatic tail, without degeneration signs (thin arrow). Follow-up MRI 2 years later demonstrates the appearance of an internal nodule of 32 mm (thick arrow) on T2WI (B) and unenhanced T1WI (C). (D) Contrast-enhanced T1WI and (E) subtraction T1WI show no enhancement of the nodule (thick arrows). Nonetheless, the nodule was biopsied, demonstrating a mucus plug.

Table 2
Analysis of degeneration signs according to Fukuoka criteria on patient and lesion levels.

	Patient level Total: 114 patients	**Lesion level** Total: 256 lesions
	Number (%)	Number (%)
Initial lesion size ≥ 30 mm	7 (6.1)	8 (3.1)
Significant increase in size (≥5 mm/2Y)[a]	23 (20.2; 5 – 25 mm)	26 (10.2; 5 – 25 mm)
Mural nodule		
Mural nodule (total)[b]	13 (11.4)	13 (5.1)
Enhancing mural nodule	4 (3.5)	4 (1.6)
Thickened cyst wall	3 (2.6)	3 (1.2)
Main pancreatic duct dilatation and parenchymal atrophy	3 (2.6)	3 (1.2)
Degeneration signs (total)	28 (24.6) based on CP 34 (29.8) based on Aps	31 (12.1) based on CP 38 (14.8) based on AP

[a] Percentages and ranges are given in parenthesis.
[b] Total number of nodules including enhancing and non-enhancing nodules (mucus plug).

anxiety and discomfort by eliminating venous cannulation and reducing scanning time. In addition to improving patient comfort by reducing scanning time, it also allows to increase the number of MRIs performed on each machine.

The utility of abbreviated MRI protocol is gaining prominence in various patient groups with not uncommon pathologies requiring regular long-term MRI follow-up, particularly in abdominal imaging for screening of hepatocellular carcinoma and prostate cancer detection [15–18]. Abbreviated protocols in pancreatic imaging could beneficial in specific patient subgroups, such as those with a history of pancreatitis, younger individuals, individuals with somatic mutations at risk of pancreatic cancer, or those with newly onset diabetes mellitus. Although guidelines for IPMNs do not currently support the use of AP, few studies demonstrated its feasibility as a replacement for CP MRI in this patient population [10,11,19].

The adoption of APs offers a dual advantage by reducing both the economic burden and the clinical implications associated with contrast administration. The time economy acquired by applying the AP is an obvious advantage especially in highly loaded centres. In the present study, the total acquisition time for AP is almost 6.5 min, which corresponds to nearly half of the required time for CP. To this, the added time for venous cannulation and contrast injection should be considered, which is difficult to calculate due to different level of expertise of

Table 3
Comparison between the three different MRI protocols on patient and lesion levels.

	Complete protocol (A)	Abbreviated protocol with DWI (B)	Abbreviated protocol without DWI (C)
Analyses on patient level			
Significant increase in size (≥5 mm/2Y)			
Present	23 (20.2)	23 (20.2)	23 (20.2)
Absent	91 (79.8)	91 (79.8)	91 (79.8)
Mural nodule			
Present	13 (11.4)	13 (11.4)	13 (11.4)
Absent	101 (88.6)	101 (88.6)	101 (88.6)
Enhancing mural nodule			
Present	4 (3.5)	–	–
Absent	110 (96.5)		
Thickened cyst wall			
Present	3 (2.6)	3 (2.6)	3 (2.6)
Absent	111 (97.4)	111 (97.4)	111 (97.4)
Main pancreatic duct dilatation and parenchymal atrophy			
Present	3 (2.6)	3 (2.6)	3 (2.6)
Absent	111 (97.4)	111 (97.4)	111 (97.4)
Degeneration signs			
Present	28 (24.6)	34 (29.8)	34 (29.8)
Absent	86 (75.4)	80 (70.2)	80 (70.2)
Analyses on lesion level			
Significant increase in size			
Present	26 (10.2)	26 (10.2)	26 (10.2)
Absent	230 (89.8)	230 (89.8)	230 (89.8)
Mural nodule			
Present	13 (5.1)	13 (5.1)	13 (5.1)
Absent	243 (94.9)	243 (94.9)	243 (94.9)
Enhancing mural nodule			
Present	4 (1.6)	–	–
Absent	252 (98.4)		
Thickened cyst wall			
Present	3 (1.2)	3 (1.2)	3 (1.2)
Absent	253 (98.8)	253 (98.8)	253 (98.8)
Main pancreatic duct dilatation and parenchymal atrophy			
Present	3 (1.2)	3 (1.2)	3 (1.2)
Absent	253 (98.8)	253 (98.8)	253 (98.8)
Degeneration signs			
Present	31 (12.1)	38 (14.8)	38 (14.8)
Absent	225 (87.9)	218 (85.2)	218 (85.2)

Categorical variables are reported as numbers and percentages in parenthesis. As observed, the presence of enhancing mural nodule defines the difference between CP and APs.

groups. The timesaving benefits associated with AP have been emphasized in previous studies, with some reporting a reduction in total time to less than 8 min [10,13,20]. These findings are consistent with the results obtained in the present study.

Previous work by Macari et al. initially reported a low discrepancy rate (4.5 %) between CP and AP, primarily attributed to expected variation in lesion categorization rather than the impact of contrast injection [19]. However, their study was limited by a small patient cohort and a short follow-up period. Nonetheless, these findings were validated in a larger patient group, showing a comparable discordance (4.6 %) between the two protocols, with no added value of CP after consensus review [11]. Pozzi-Mucelli et al. not only confirmed these results but also demonstrated a substantial cost reduction, as low as 25 % of CP costs, with AP implementation [10]. A recently ultrashort AP protocol proposed by Johansson et al. provided a nearly identical information compared to CP [13]. The authors proposed an AP protocol including T2WI and MRCP, which is comparable to the present study except for the exclusion of the coronal T2WI. Furthermore, some studies demonstrated the benefits of replacing conventional 3D MRCP by breath-hold 3D MRCP in reducing the time acquisition in AP [14,20]. Kang et al. achieved 100 % sensitivity and negative predictive value, which is comparable to the results of the present study [20]. The high sensitivity of proposed APs permits the detection of all IPMN degeneration signs, and its high NPV allows to confidently releasing the patients without the need of contrast media injection. In addition, the specificity of 93.5 % and the PPV of 83.3 % obtained in this current study were substantially higher compared to previously reported of 36.7 % and 36.7 %, respectively [20]. Indeed, APs discerned all degeneration signs while overestimating the presence of mural nodule in a small number of patients. This discrepancy arose from the consideration of mucus plugs as mural nodule, attributable to the absence of contrast media injection. However, the high specificity indicates that this overestimation could be negligible.

While prior studies mainly focused on the additional role of contrast-enhanced sequences, the significance of time-consuming DWI was not thoroughly addressed. In the present study, by designing two APs, we displayed no additional value for DWI beyond redundant contrast-enhanced sequences. Our results indicate that the AP including only T2WI and MRCP sequences holds the same diagnostic value as a CP including supplementary DWI and dynamic images. While DWI may not contribute independently to the detection of additional degeneration signs, its inclusion in AP warrants consideration. In nearly 2 % of patients with BD-IPMN, an associated pancreatic adenocarcinoma, elsewhere in the pancreatic parenchyma, has been reported [21]. By this knowledge, DWI may offer particular benefits in specific patient subgroups, including those with a history of pancreatitis, individuals with somatic mutations, or those experiencing newly onset diabetes mellitus.

Moreover, it is imperative to note that previously proposed AP protocols differ between various studies. The majority of studies suggest an AP including T2WI and T1WI while MRCP sequences seems to be mandatory in IPMN follow-up [10,11,19]. We recommend retaining MRCP in the AP due to its superior depiction of mural nodules and safety from the partial volume effect, which could be observed with higher section thickness T2WI. Furthermore, with the development of breath-hold MRI, a rapid acquisition in less than 20 s in cooperative patients is feasible [22,23].

There are some limitations in this study that should be acknowledged. Firstly, the retrospective nature introduces an inevitable selection bias. However, efforts were made to include all consecutive patients routinely followed for BD-IPMN to mitigate this bias. Secondly, the study was conducted across four different MRI scanners, introducing heterogeneity. However, it enhances the generalizability of the results to routine clinical practice with diverse machines. Thirdly, the median interval between baseline and follow-up MRIs was 794 days, which may have influenced the results due to its relatively short duration. Although a longer surveillance period could potentially increase the detection of the rate of cystic degeneration, it's important to note that the performance of detection of degeneration signs, our main focus, is not directly dependent on the length of the follow-up period. Additionally, similar studies have been conducted with follow-up periods of comparable length. Fourthly, relying on a single reader could weaken the results. We attempted to reduce this confounding factor by seeking agreement before the study. The diagnostic criteria for IPMN are also well-established and interreader agreement has been extensively analysed in prior literature. Finally, the lack of pathological confirmation for all patients with degeneration signs may affect the interpretation of presented results. Yet, the latter was inevitable while patients refused the EUS.

In conclusion, the detection of BD-IPMN degeneration can be confidently achieved with AP Including T2WI and MRCP, offering benefits, such as patient comfort, improved MRI accessibility, and reduced dedicated time for image analysis. These findings should encourage the

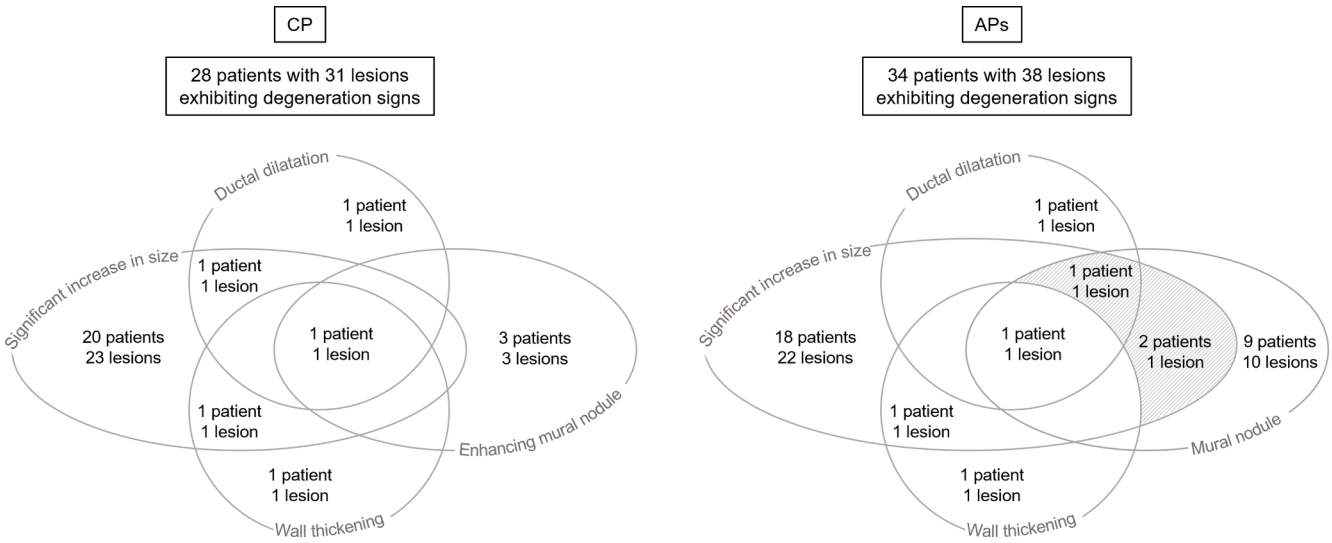

Fig. 4. Distribution of degeneration signs with CP and APs on both patient and lesion levels.

Table 4
Diagnostic performance of APs.

	Sensitivity	Specificity	PPV	NPV	Accuracy
Analyses on patient level					
Percentage (%)	100	93.5	83.3	100	95.1
95 % CI	87.7 – 100	86.3 – 97.8	69.7 – 91.5	95.8 – 100	89.5 – 98.2
Analyses on lesion level					
Percentage (%)	100	97.0	82.0	100	97.4
95 % CI	88.8 – 100	93.9 – 98.8	68.8 – 90.4	98.4 – 100	94.6 – 98.9

Values are given in percentages. CI: confidence intervals.

integration of abbreviated protocols into clinical guidelines and daily routine practice.

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Disclosures

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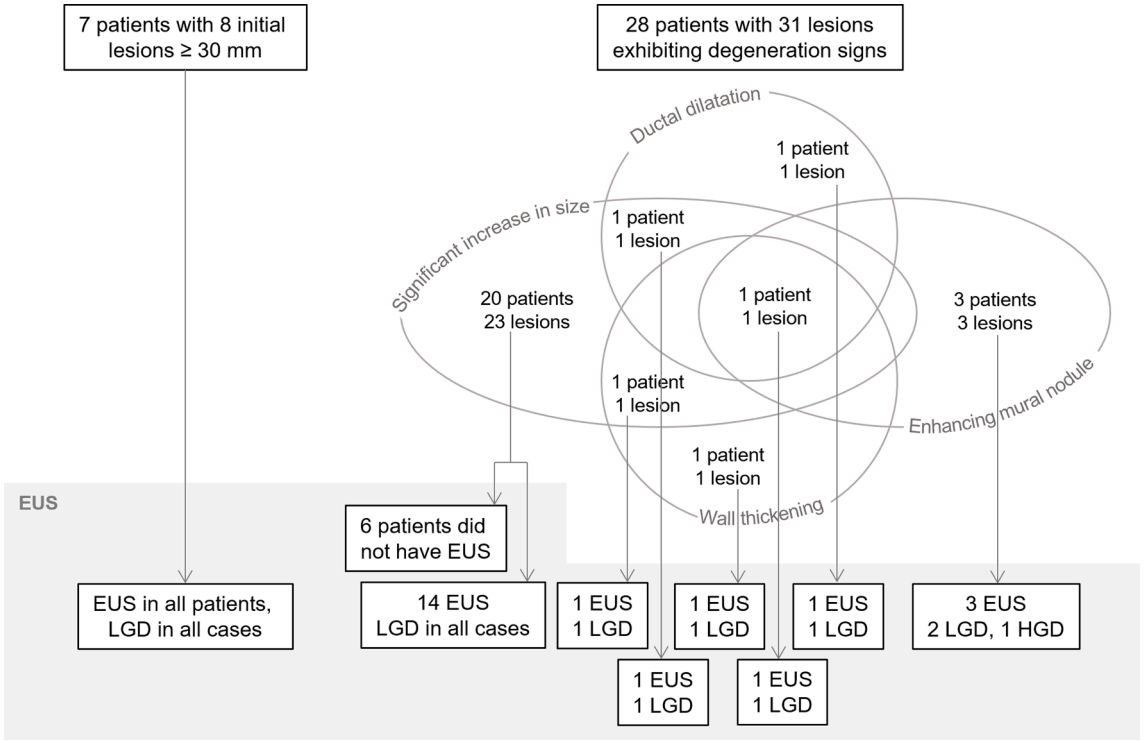

Fig. 5. Radiologic and pathology correlation according to CP and EUS.

CRediT authorship contribution statement

Sonaz Malekzadeh: Writing – review & editing, Writing – original draft, Validation, Supervision, Formal analysis, Data curation, Conceptualization. **Roberto Cannella:** Validation, Supervision, Methodology, Formal analysis. **Ian Fournier:** Data curation, Validation. **Philippe Hiroz:** Data curation, Validation. **Christian Mottet:** Data curation, Validation. **Christophe Constantin:** Conceptualization, Validation. **Lucien Widmer:** Conceptualization, Data curation, Formal analysis, Investigation, Supervision, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ejrad.2024.111455.

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