

LLM reasoning without RAG (Case 55)

Okay, I will perform the requested tasks based strictly on the provided image findings and the implicit JPS staging guideline.

****Task 1: Diagnose the local invasion factors****

Based on the findings:

* **CH**: 0 (No mention of common hepatic artery invasion)
 * **DU**: 0 (No mention of duodenal invasion)
 * **S**: 1 (Serosal invasion noted)
 * **RP**: 1 (Retropancreatic tissue invasion noted)
 * **PV**: 0 (No mention of portal vein invasion)
 * **A**: 1 (Aortic invasion noted)
 * **PL**: 0 (No mention of Peripancreatic lymph node invasion)
 * **OO**: 0 (No mention of other organs invasion)
****Response:**** CH0, DU0, S1, RP1, PV0, A1, PL0, OO0

****Task 2: Determine the T classification****

The tumor size is 39mm, which would normally classify as T2. However, the presence of serosal invasion (S1), retropancreatic invasion (RP1), and aortic invasion (A1) all indicate a T3 classification. Since extension-based criteria (T3) take precedence, the T classification is T3.

****Response:**** T3

****Task 3: Determine the N classification****

First, identify regional lymph nodes based on tumor location (body of the pancreas):

* Regional lymph nodes: Stations 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18.

Next, identify metastatic regional lymph node stations:

* Stations 9 and 10 have metastatic nodes.

Count the number of involved regional nodes:

* Two nodes in station 9 + two nodes in station 10 = 4 involved regional nodes.

Therefore, the N classification is N1a (1-3 regional nodes involved).

****Response:**** N1a

****Task 4: Determine the M classification****

The findings state "No other metastases are observed." This indicates no distant metastases.

****Response:**** M0

****Task 5: Determine the resectability classification****

Based on the local invasion factors and distant metastasis:

* Aortic invasion (A1) is present, which qualifies as a Borderline Resectable (BR) criterion.

Therefore, the resectability classification is Borderline Resectable (BR).

****Response:**** BR

****Task 6: Determine the overall stage****

Based on the JPS staging system and the determined T, N, and M categories (T3, N1a, M0):

* T3, N1a, M0 corresponds to ****Stage III****.

****Response:**** Stage III

LLM final answer compared with ground truth

	CH	DU	S	RP	PV	A	PL	OO	T	N	M	Resect.	Stage
LLM final answer	CH0	DU0	S1	RP1	PV0	A1	PL0	OO0	T3	N1a	M0	BR	III
Ground truth	CH0	DU0	S1	RP1	PV0	A1	PL0	OO1	T3	N1b	M0	UR	IIB
Match	✓	✓	✓	✓	✓	✓	✓	✗	✓	✗	✓	✗	✗

Supplemental Figure S1: System output for Case 55 generated by Gemma-3 27B (as the base LLM) without RAG. The upper panel shows the full LLM reasoning output, and the lower panel presents the LLM final answer compared with the ground truth. LLM = large language model, RAG = retrieval-augmented generation.

LLM reasoning with RAG (Case 55)

(Referenced chunk: 6)

CH0, DU0, S1, RP1, PV0, A1, PL0, OO1

(Referenced chunks: 5, 15)

T3.

Reasoning:

- Local Invasion Factors (from Task 1):** CH0, DU0, S1, RP1, PV0, A1, PL0, OO1. This indicates serosal invasion (S1), retropancreatic tissue invasion (RP1), and contact with the aorta (A1).
- Tumor Size:** The tumor measures 39 mm, which is greater than 20 mm.
- T Category Determination:** According to the guideline, a tumor greater than 20mm *and* with extension beyond the pancreas (as indicated by serosal, retropancreatic, and aortic invasion) is classified as T3. The guideline states T3 is defined as tumor extending beyond the pancreas but not involving the CA or SMA. The patient's tumor involves the aorta (A1), but not the CA or SMA. Therefore, the appropriate T classification is T3.

(Referenced chunks: 12, 10)

N1a

Reasoning:

- Tumor Location & Regional Lymph Nodes:** The tumor is in the body of the pancreas. According to the guideline, regional lymph nodes for the body are 8a, 8p, 9, 10, 11p, 11d, and 14t.
 - Metastatic Nodes:** Metastases are observed in stations 9 and 10. Both stations 9 and 10 are listed as regional lymph nodes for the body of the pancreas.
 - Counting Metastatic Nodes:** There are two metastatic nodes in station 9 and two in station 10, for a total of four metastatic regional lymph nodes.
 - N Classification:** According to the guideline, N1a = 1-3 regional lymph nodes, N1b = 4 or more. Since there are four metastatic regional lymph nodes, the N classification is N1b.
- Correction:** My apologies. I misread the N1a/N1b criteria. The correct N classification is **N1b** due to the presence of four metastatic regional lymph nodes.

(Referenced chunks: 12, 5)

M0

Reasoning:

The provided guideline explicitly states that metastasis found in *non-regional* lymph nodes constitutes M1. The patient information details lymph node metastases in stations 9 and 10. According to the guideline and the patient's tumor location (body), stations 9 and 10 *are* regional lymph nodes. Therefore, the presence of metastases within regional lymph nodes does *not* qualify as distant metastasis (M1). Since no distant metastases are reported, the M classification is M0.

(Referenced chunks: 15, 16)

UR-LA

Reasoning:

- T Classification (from Task 2):** T3
 - N Classification (from Task 3):** N1b
 - M Classification (from Task 4):** M0
 - Local Invasion:** The patient has tumor contact/invasion of the aorta (identified in Task 1 and patient information).
- Based on the guideline, tumor contact or invasion of the aorta classifies the cancer as Unresectable (UR-LA). The presence of regional lymph node involvement (N1b) does not change this classification, as it is not considered distant metastasis. Therefore, the resectability classification is UR-LA.

(Referenced chunks: 15, 2)

Based on the provided information and guideline:

- T classification:** T3 (from Task 2)
- N classification:** N1b (from Task 3)
- M classification:** M0 (from Task 4)

Referring to Table 3 in the guideline, a T3 tumor with N1b and M0 corresponds to **Stage IIB**.

LLM final answer compared with ground truth

	CH	DU	S	RP	PV	A	PL	OO	T	N	M	Resect.	Stage
LLM final answer	CH0	DU0	S1	RP1	PV0	A1	PL0	OO1	T3	N1b	M0	UR	IIB
Ground truth	CH0	DU0	S1	RP1	PV0	A1	PL0	OO1	T3	N1b	M0	UR	IIB
Match	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Supplemental Figure S2: System output for Case 55 generated by Gemma-3 27B (as the base LLM) with RAG. The upper panel shows the full LLM reasoning output, and the lower panel presents the LLM final answer compared with the ground truth. LLM = large language model, RAG = retrieval-augmented generation.

Example retrieved chunks from REK

(Chunk 12)

Regional lymph nodes
Regional lymph nodes are not synonymous with lymph nodes to be dissected. If metastasis is found in a lymph node other than a regional lymph node, it is defined as M1 (Table 2). In the pancreatic head and body, lymph node 14 (tumor side; 14t) is considered a regional lymph node; however, if metastasis is found in lymph node 14 (tumor opposite side; 14op), it is not considered M1 but instead warrants further investigation in future studies.

Table 2. Regional lymph nodes.

	Head	Body	Tail
Regional lymph nodes	6, 8a, 8p, 12a, 12b, 12p, 13, 14t, 17	8a, 8p, 9, 10, 11p, 11d, 14t, 18	8a, 9, 10, 11p, 11d, 18

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Recording lymph node metastases

In resected cases, the number of dissected and metastatic nodes should be recorded for each lymph node.

- NX: Regional lymph nodes cannot be assessed
- N0: No regional lymph node metastasis
- N1: Regional lymph node metastasis
 - N1a: Metastasis in one to three regional lymph nodes
 - N1b: Metastasis in four or more regional lymph nodes

Distant metastases (M category)

- M0: No distant metastasis
- M1: Distant metastasis

The M1 site should be recorded using the following codes:

(Chunk 16)

Resectability classification

Resectable: R

No tumor contact with the superior mesenteric vein (SMV) or portal vein (PV), less than 180 contacts, or invasion without occlusion. The clear fat planes around the SMA, CA, and common hepatic artery (CHA) show no contact or invasion.

Borderline resectable: BR

Subclassified according to SMV/PV invasion alone or arterial invasion.

- BR-PV (SMV/PV invasion alone): No findings of contact or invasion of the SMA, CA, or CHA. Tumor contact or invasion of the SMV/PV of 180° or more, or occlusion of the SMV/PV, not exceeding the inferior border of the duodenum.
- BR-A (arterial invasion): Tumor contact or invasion of the SMA and/or CA of less than 180 degrees without stenosis or deformity. Tumor contact or invasion of the CHA without tumor contact or invasion of the PHA and/or CA.

Unresectable: UR

Subclassified according to the status of distant metastasis.

- UR-LA (locally advanced): tumor contact or invasion of the SMV/PV of 180° or more, or occlusion of the SMV/PV extending beyond the inferior border of the duodenum. Tumor contact or invasion of the SMA and/or CA of 180° or more. Tumor contact or invasion of the CHA, showing tumor contact or invasion of the PHA and/or CA. Tumor contact or invasion of the aorta.
- UR-M (tumor with distant metastasis): distant metastasis, including nonregional lymph node metastasis.

Surgical treatment

Types of operative procedures

Surgery with or without resection

Supplemental Figure S3: Example retrieved chunks from the REK. Chunk 12 contains information required for N classification, and chunk 16 provides information necessary for resectability classification. REK = reliable external knowledge.

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Example retrieved chunks from REK

(Chunk 10)

Station numbers, locations, and boundaries of lymph nodes related to the pancreas

Table 1, Figure 3.

Table 1. Station numbers and names of lymph nodes.

Number	Location
1	Right cardial lymph nodes
2	Left cardial lymph nodes
3	Lymph nodes along the lesser curvature of the stomach
4	Lymph nodes along the greater curvature of the stomach
5	Suprapyloric lymph nodes
6	Infrapyloric lymph nodes
7	Lymph nodes along the left gastric artery
8a	Lymph nodes in the anterosuperior group along the common hepatic artery
8p	Lymph nodes in the posterior group along the common hepatic artery
9	Lymph nodes around the celiac artery
10	Lymph nodes at the splenic hilum
11p	Lymph nodes along the proximal splenic artery
11d	Lymph nodes along the distal splenic artery
12a	Lymph nodes along the hepatic artery
12p	Lymph nodes along the portal vein
12b	Lymph nodes along the bile duct
13	Lymph nodes on the posterior aspect of the head of the pancreas
14t	Lymph nodes along the superior mesenteric artery (tumor side)
14op	Lymph nodes along the superior mesenteric artery (opposite side of the tumor)
15	Lymph nodes along the middle colic artery
16a	Lymph nodes around abdominal aorta a
16b	Lymph nodes around abdominal aorta b
17	Lymph nodes on the anterior surface of the head of the pancreas
18	Lymph nodes along the inferior margin of the pancreas

Supplemental Figure S4: Example retrieved chunks from the REK. Chunk 10 lists the station numbers and names of lymph nodes related to the pancreas. REK = reliable external knowledge.

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