Risk factors for abdominal wall pseudohernia after percutaneous cryoablation of renal cell carcinoma

Takahiro Higuchi[1], Kanichiro Shimizu[1], Keitaro Enoki[1], Kenji Motohashi[1], Yoshihiko Kameoka[1], Naoki Kurata[1], Jun Miki[2], Haruki Sekiguchi[3], Shunichi Sadaoka[1]

[1]Department of Radiology, The Jikei University, School of Medicine, Chiba, Kashiwa Hospital, Japan
[2]Department of Urology, The Jikei University, School of Medicine, Chiba, Kashiwa Hospital, Japan
[3]Department of Cardiology, Tokyo Women's Medical University, Tokyo, Japan

Videosurgery Miniinv 2022; 17 (1): 188–193
DOI: https://doi.org/10.5114/wiitm.2021.107752

Abstract

Introduction: *Percutaneous cryoablation (PCA) is increasingly recognized as a feasible minimally invasive, nephron-sparing treatment for renal cell carcinomas, with comparable efficacy to nephrectomy. The development of abdominal wall pseudohernia (AWP) is a rare complication of PCA for renal masses, which can negatively impact patients' quality of life.*

Aim: *To retrospectively evaluate the risk factors and prognosis for AWP after PCA and, based on these results, to discuss strategies to lower the risk of AWP associated with image-guided PCA for renal masses.*

Material and methods: *We retrospectively studied 117 PCAs performed for renal masses in 92 patients, between 2016 and 2019, at our hospital. We compared the following clinical characteristics (age, sex, body mass index, tumour diameter, RENAL nephrometry score, procedural details, transcatheter arterial embolization, dissection techniques, number of cryoneedles used, location of needles, and location of ice ball) between those who developed AWP and those who did not.*

Results: *Of the 117 PCAs (92 patients) included in our study group, AWP complications were observed in 6 (5.1%) procedures. Puncture through the erector spinae muscle ($p < 0.01$) and non-use of hydro- or pneumo-dissection ($p = 0.01$) were identified as risk factors for AWP.*

Conclusions: *Although PCA is relatively safe to perform and the occurrence of an associated AWP is a rare and infrequent complication, the risk for AWP could be further decreased by avoiding punctures through the erector spinae muscle and using hydro- or pneumo-dissection.*

Key words: *abdominal wall pseudohernia, percutaneous cryoablation, renal cell carcinoma.*

Introduction

Percutaneous cryoablation (PCA) is increasingly recognized as a feasible minimally invasive, nephron-sparing treatment for renal cell carcinomas (RCCs), with comparable efficacy to nephrectomy [1]. PCA is suitable for patients who are at risk for complications with open surgery, as well as for those with multiple renal tumours or a single kidney [2]. Although PCA for RCCs is generally considered safe, there have been reports of complications [3], including incidental nerve injury, which can result in abdominal wall pseudohernia (AWP), a well-known complication of ablation procedures [4].

AWP is defined as a marked protrusion of the abdominal muscle due to neuropathy or denervation.

Address for correspondence
Dr. Takahiro Higuchi, Department of Radiology, Kashiwa Hospital, School of Medicine, The Jikei University, Chiba, Japan,
e-mail: h.takahiro0202@gmail.com

AWP can be diagnosed without any blood tests or imaging by confirming a recent history of nerve injury, bulging of the abdominal wall in the standing position, and absence of an abdominal wall reflex at the location of the nerve lesion. Of note, there are generally no findings specific to AWP on computed tomography (CT) or other types of imaging [5]. Moreover, although the protrusion with an AWP resembles a hernia, there is no actual muscular disruption, with all muscle and fascial layers remaining intact [6]. As the use of renal cell carcinoma ablation continues to expand, the incidence of associated neurologic complications, such as AWP, is likely to increase.

Aim

This study aimed to retrospectively evaluate the risk factors and prognosis for AWP after PCA and, based on these results, discuss strategies to lower the risk of AWP associated with image-guided PCA for renal masses.

Material and methods

Statement of ethics

Ethics approval was obtained from our institutional review board, with the requirement for patient informed consent waived owing to the retrospective design of the study and the use of anonymized data. Our study adhered to the ethical guidelines of the Helsinki Declaration of 1975, as revised in 2000.

Indications for PCA

PCA is indicated for patients who are poor candidates for open surgery due to medical comorbidities, as well as for those with a single kidney, those who are likely to develop multifocal recurrent renal tumours because of hereditary conditions such as Von Hippel-Lindau syndrome, and those who refuse surgical intervention. Transcatheter arterial embolization (TAE) is performed prior to PCA for patients in whom renal tumours were poorly visualized on non-contrast CT because of their endophytic location or small size.

Study group

A search of our institutional renal tumour ablation database identified 117 cases in 92 patients who underwent PCA for the treatment of renal masses between 2016 and 2019 in our hospital. Relevant patient demographics, tumour characteristics, and procedural details are summarized in Table I.

The mean age of patients at the time of the procedure was 65 (range: 37–89) years, with the majority being male (76%, 89/117). The mean body mass index (BMI) of patients was 23.8 ±4.0 (range: 14.7–37.2) kg/m^2. The mean tumour size recorded on CT images was 26.5 ±9 (range: 3–55) mm, with a mean RENAL nephrometry score of 7.0 ±1.6 (range: 4–10).

Cryoablation technique

All patients provided informed consent for the procedures. Of the 117 cases, TAE had previously been performed in 105 (89.7%) using a 5 : 2 mixture of absolute ethanol and lipiodol. All PCA procedures were performed in the CT suite at our hospital, with the patient conscious. An 80-detector row CT scanner (Aquilion™ PRIME, Toshiba Medical Systems, Tochigi, Japan) was used for visual guidance. For all PCAs, cryoablation was performed using the CryoHit system (Galil Medical, Yokneam, Israel), with 17-gauge cryoneedles (IceRod, Galil Medical, Yokneam, Israel). Cryoneedles were inserted percutaneously, under local anaesthesia, and directed to the target tumour under CT fluoroscopy. The ablation cycle consisted of 15-min freezing, followed by a 5-min period of thawing, and a subsequent 15-min period of refreezing. Monitoring for ice ball formation was performed by CT at 5-min intervals during the ablation procedure. When additional ablation was required, the position

Table I. Clinicopathological characteristics of the study group (n = 117 cases)

Characteristics	Value
Age [years][a]	65 ±14
Male (n)	89
BMI [kg/m^2][a]	23.8 ±4
Tumour size [mm][a]	26.5 ±9
Renal nephrometry score[a]	7 ±1.6
Prior TAE (n)	105
Hydro- or pneumo-dissection (n)	58
Number of needles[a]	3.1 ±0.8
Median distance between each needle [mm][a]	18.6 ±13.4
Punctures through the erector spinae muscle (n)	15
Ice ball involvement of abdominal wall (n)	38
Ice ball involvement of a rib (n)	28

[a]Mean ± standard deviation, n – count, TAE – transcatheter arterial embolization, BMI – body mass index.

of the cryoneedles was adjusted to the new target location and additional freezing performed. Hydro- or pneumo-dissection was performed in 58/117 (49.6%) PCA procedures to avoid freezing injury to adjacent organs.

On average, 3.1 (range: 2–5) cryoneedles were used, with a mean distance interval between each needle of 18.6 ±13.4 (range: 4–90) mm. The distance between the needles was measured on CT in the proper slices of the skin surface from 3 directions. The median value was applied because of variation in needle position between PCA cases. Punctures were performed through the erector spinae muscle in 15 PCA procedures and via a more ventral route in the remaining 102 procedures.

All ice ball formations were evaluated using intraoperative CT to confirm whether the ice ball included the abdominal wall and ribs after freezing. Ice ball formation during cryotherapy was observed in the abdominal wall in 32.5% (38/117) of cases and involved a rib in 23.9% (28/117) of cases.

Post-procedure follow-up

Follow-up for the presence of an AWP was performed the day after the procedure. AWP was further assessed on subsequent follow-up outpatient visits at 1, 3, 6, and 12 months after PCA during the first year and every 6 months thereafter. AWP was defined as a protrusion of the abdominal wall that a patient complained about or which was identified by the physician by confirmation of a bulging of the abdominal wall in the standing position or absence of abdominal wall reflex at the site of nerve lesion.

Statistical analysis

For analysis, patients were classified into the AWP or non-AWP groups, with the following factors compared between the 2 groups using a chi-squared (χ^2) or Fisher's exact tests for categorical variables and the Wilcoxon rank sum test for continuous variables: age, sex, BMI, tumour size, RENAL nephrometry score, prior TAE, use of hydro- or pneumo-dissection, number of cryoneedles used, the median distance between each needle (measured from reconstruction of intraoperative multiplane CT images), the puncture site (dichotomized as through the erector spinae muscle or via a more ventral route), and extension of the ice ball into the abdominal wall or rib. Continuous factors were presented as mean and standard deviation (SD) or median (range), as appropriate for the data distribution, with categorical variables reported as a count (%). Between-group comparisons were evaluated using Student's *t*-test for continuous variables and Fisher's exact test for categorical variables.

Statistical analyses were performed using the Statistical Package for Social Sciences (IBM SPSS statistics 25.0 for Windows, SPSS Inc., Chicago, IL), with a p-value < 0.05 indicating significance.

Results

Postoperatively, AWP developed in 6/117 (5.1%) cases. Among these, 5 resolved spontaneously within 6 months of the procedure, with the AWP persisting in 1 case. Between-group comparisons of measured factors are reported in Table II. Among the factors measured, punctures through the erector spinae muscle ($p < 0.01$) and use of hydro- or pneumo-dissection ($p = 0.01$) were significantly different between the 2 groups. Of the 15 cases for which PCA was performed using a puncture through the erector spinae muscle, AWP developed in 3. There was no incidence of AWP among the 58 PCAs in which hydro- or pneumo-dissection was used.

Ice ball involvement was not significantly different between the 2 groups. Involvement of the abdominal wall was observed in 3 cases in the AWP group and 35 cases in the non-AWP group ($p = 0.35$). Ice ball involvement of the ribs was also not significantly different. Involvement of the rib was observed in 3 patients in the AWP group and in 25 cases in the non-AWP group ($p = 0.12$).

Discussion

AWP development is a well-recognized complication of abdominal surgery, herpes zoster infection, diabetes mellitus, and iatrogenic trauma [6–13]. Knowledge of the anatomical course of the intercostal nerves can lower the risk for AWP during laparoscopic surgery [14]. The management of AWP generally includes pain relief, mechanical support using a corset, and physiotherapy. Recovery of intercostal nerve function usually leads to resolution of the pseudohernia. In our study, among the 6 patients who developed an AWP after PCA, the AWP resolved in 5, and the AWP persisted in the other patient due to irreversible nerve damage. AWP, as a permanent complication of PCA

Table II. Results of the 117 percutaneous cryoablation procedures

Parameter	AWP (+)	AWP (-)	*P*-value
Number of cases	6	111	
Age [years][a]	65 (60–75)	67 (55–77)	0.99
Male, *n* (%)	5 (83.3)	84 (75.7)	0.67
BMI [kg/m^2][a]	23.6 (20.8–27.1)	23.3 (20.9–26.7)	0.43
Tumour size [mm][a]	23 (15.8–30.0)	25 (20–32)	0.07
RENAL score, *n* (%):			0.58
4	0	8 (7.2)	
5	2 (33.3)	10 (9.0)	
6	1 (16.7)	28 (25.2)	
7	3 (50.0)	25 (22.5)	
8	0	14 (12.6)	
9	0	19 (17.1)	
10	0	7 (6.3)	
Prior TAE, *n* (%)	5 (83.3)	100 (90.1)	0.6
Hydro- or pneumo-dissection, *n* (%)	0 (0.0%)	58 (52.3)	0.01
Number of needles, *n* (%):			0.85
2	2 (33.3)	29 (26.1)	
3	3 (50.0)	44 (39.6)	
4	1 (16.7)	36 (32.4)	
5	0	2 (1.8)	
Median distance between each needle [mm][a]	12 (8.5–13.5)	15 (11–21.5)	0.89
Punctures through the erector spinae muscle, *n* (%)	3 (50.0)	12 (10.8)	< 0.01
Ice ball involvement, *n* (%):			
Abdominal wall involvement	3 (50.0)	35 (31.5)	0.35
Rib involvement	3 (50.0)	25 (22.5)	0.12

[a]*Mean (range), BMI – body mass index, TAE – transcatheter arterial embolization, AWP – abdominal wall pseudohernia.*

due to irreversible nerve damage, can adversely affect an individual's quality of life.

With PCA for renal masses, the risk of nerve injury is higher for radio-frequency ablation (RFA) (3.5%) than for PCA (0.6%) [3, 15]. Although neurological deficits have been reported after PCA [3, 16], to our knowledge, the development of an AWP after PCA has not previously been described. Moreover, although the sequalae of nerve injury secondary to RFA tend to be permanent, those resulting from PCA tend to be temporary, resolving within 6 months in most patients [3, 17].

Nerve injuries resulting from PCA procedures are rare [18, 19]. In their report of 139 patients who underwent PCA, Blute *et al.* [18] did not identify a case of nerve injury. Similarly, Okhunov *et al.* [19] did not report any nerve injury in their 190 cases of PCA. In their report of 171 tumours in 147 patients who underwent PCA, Faiz *et al.* [20] reported 1 case of paraesthesia which was considered as a nerve injury. In their case series of 311 PCA procedures, Atwell *et al.* [3] reported 2 cases of nerve injury due to motor nerve injury (or unknown cause of paralysis). Of these, very few cases of AWP have been reported.

Although rare, the possibility of AWP should be carefully evaluated after PCA, including assessment with the patient in the upright position because the AWP may be unnoticeable in the supine position. Diagnosis of an AWP is important because the muscles of the anterior abdominal wall are responsible for maintaining optimal intra-abdominal pressure and supporting the abdominal viscera. These mus-

cles are innervated by the intercostal nerves and by the iliohypogastric and ilioinguinal nerves, with AWP resulting from injury to these nerves. These nerves emanate from their spinal roots and travel through the abdominal wall [4]. In our study, we noticed that punctures located more dorsally (namely, punctures through the erector spinae muscle) were associated with a greater risk for AWP and for nerve injury than punctures located in a more ventral position ($p < 0.01$). This is an interesting point to consider within the context of research on abdominal nerve blocks for thoracic and abdominal surgery, which includes various approaches, such as transversus abdominis plane (TAP), intercostal, rectus sheath (RS), pararectus and ilioinguinal/iliohypogastric, quadratus lumborum, and paravertebral blocks. This body of research demonstrates that a posterior TAP block (PTAP) is more effective than a lateral TAP block (LTAP), with both TAP and LTAP blocks being more effective than RS, pararectus, and ilioinguinal/iliohypogastric blocks [20, 21]. These findings indicate that a more dorsal nerve block might provide a more effective anaesthesia. This differential effectiveness is reflected in the anatomy of the cutaneous branches of the intercostal, subcostal, and lumbar nerves. At the trunk, the dorsal branch of thoracic nerves gives off an outer cutaneous branch, which runs in a median direction to the ventral trunk, penetrating the rectus sheath and rectus abdominis to become the anterior cutaneous branch. The anterior cutaneous branch principally innervates the central region of the trunk, with the outer cutaneous branch innervating the dorsal lateral portion of the trunk, including the anterior abdominal wall [22]. Owing to this anatomy, PTAP can provide a greater anaesthetic effect than LTAP but carries a higher risk for iatrogenic injury. This would explain the identification of a puncture through the erector spinae muscle as an increased risk factor for AWP.

We also identified the use of water/air dissection as a factor that lowered the risk of AWP. Hydro- or pneumo-dissection was performed to maintain a distance between the target RCC and adjacent organs, such as the intestinal tract and iliopsoas muscle. As a secondary outcome, hydro- or pneumo-dissection may have also protected nerves traveling in the abdominal wall from the effects of cryotherapy, thus reducing the risk of AWP. Of note, the extension of the ice balls, either in the abdominal wall ($p = 0.35$) or rib cage ($p = 0.12$), did not increase the risk of AWP. A previous study indicated that the lethal perimeter was < 1 cm from the leading edge of an ice ball for all cryoprobe configurations [23], which would explain the absence of an association between ice ball formation and AWP in our study. Furthermore, the introduction of fluid/air into the peri- and paranephric fat may further insulate the cutaneous nerves of the abdominal wall from the target tumour [24]. This would explain the lower risk of AWP with the use of water/air dissection.

Careful pre-ablation planning is required to avoid AWP, including optimal patient positioning, avoiding punctures through the erector spinae muscle, and the targeted positioning of the cryoablation device. Additional care should be taken if a dorsal approach for the cryoneedle is required. When possible, hydro- or pneumo-dissection should be used to lower the risk of the effect of freezing on the intercostal, subcostal, and lumbar nerves.

This study is primarily limited by its retrospective design and small sample size. The true incidence of AWP requires larger studies and a future meta-analysis to be accurately quantified.

Conclusions

Although PCA is relatively safe and the occurrence of associated AWP is a rare and infrequent complication, the risk of AWP could be further decreased by avoiding punctures through the erector spinae muscle and using hydro- or pneumo-dissection.

Conflict of interest

The authors declare no conflict of interest.

References

1. Maria T, Georgiades C. Percutaneous cryoablation for renal cell carcinoma. J Kidney Cancer VHL 2015; 2: 105-13.
2. Dindo D, Demartines N, Clavien PA. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. Ann Surg 2004; 240: 205-13.
3. Atwell TD, Carter RE, Schmit GD, et al. Complications following 573 percutaneous renal radiofrequency and cryoablation procedures. J Vasc Interv Radiol 2012; 23: 48-54.
4. Bhayani SB, Allaf ME, Su LM, Solomon SB. Neuromuscular complications after percutaneous radiofrequency ablation of renal tumors. Urology 2005; 65: 592.
5. Hori H, Fukuchi T, Sugawara H. At-a-glance diagnosis of postherpetic abdominal pseudohernia. Int J Infect Dis 2020; 95: 371-2.
6. Butensky AM, Gruss LP, Gleit ZL. Flank pseudohernia following posterior rib fracture: a case report. J Med Case Rep 2016; 10: 273.

7. Chakraborty PP, Singha A, Bhattacharjee R, et al. Abdominal pseudohernia: a manifestation of diabetic truncal radiculoneuropathy. BMJ Case Rep 2016; 2016. https://doi.org/10.1136/bcr-2016-215605.
8. Oliveira PD, dos Santos Filho PV, de Menezes Ettinger JE, et al. Abdominal-wall postherpetic pseudohernia. Hernia 2006; 10: 364-6.
9. Chernev I, Dado D. Segmental zoster abdominal paresis (zoster pseudohernia): a review of the literature. PMR 2013; 5: 786-90.
10. Weeks RA, Thomas PK, Gale AN. Abdominal pseudohernia caused by diabetic truncal radiculoneuropathy. J Neurol Neurosurg Psychiatry 1999; 66: 405.
11. Chatterjee S, Nam R, Fleshner N, et al. Permanent flank bulge is a consequence of flank incision for radical nephrectomy in one half of patients. Urol Oncol 2004; 22: 36-9.
12. Gardner GP, Josephs LG, Rosca MM, et al. The retroperitoneal incision. An evaluation of postoperative flank 'bulge'. Arch Surg 1994; 129: 753-6.
13. Durham-Hall A, Wallis S, Butt I, et al. Abdominal wall pseudohernia following video-assisted thoracoscopy and pleural biopsy. Hernia 2009; 13: 93-5.
14. Durham-Hall, Wallis S, Butt I, et al. Abdominal wall pseudohernia following video-assisted thoracoscopy and pleural biopsy. Hernia 2009; 13: 93-5.
15. Philip A, Gupta S, Ahrar K, et al. A spectrum of nerve injury after thermal ablation: a report of four cases and review of the literature. Cardiovasc Intervent Radiol 2013; 36: 1427-35.
16. Breen DJ, Bryant TJ, Abbas A, et al. Percutaneous cryoablation of renal tumours: outcomes from 171 tumours in 147 patients. BJU Int 2013; 112: 758-65.
17. Georgiades CS, Hong K, Bizzell C, et al. Safety and efficacy of CT-guided percutaneous cryoablation for renal cell carcinoma. J Vasc Interv Radiol 2008; 19: 1302-10.
18. Blute ML Jr, Okhunov Z, Moreira DM, et al. Image-guided percutaneous renal cryoablation: preoperative risk factors for recurrence and complications. BJU Int 2013; 111: E181-5.
19. Okhunov Z, Moreira DM, Del Junco M, et al. Predictors of complications after percutaneous image-guided renal cryoablation for t1a renal cortical neoplasms. J Endourol 2017; 31: 7-13.
20. Faiz SHR, Alebouyeh MR, Derakhshan P, et al. Comparison of ultrasound-guided posterior transversus abdominis plane block and lateral transversus abdominis plane block for postoperative pain management in patients undergoing cesarean section: a randomized double-blind clinical trial study. J Pain Res 2018; 11: 5-9.
21. Vonu PM, Campbell P, Prince N, et al. Analgesic efficacy of nerve blocks after abdominoplasty: a systematic review. Aesthet Surg J 2020; 24: 1208-15.
22. Shido A. Ultrasound-guided peripheral nerve blocks for upper abdominal surgery – where we are and where we will be. J Jpn Soc Clin Anesth 2010; 30: 959-66.
23. Littrup PJ, Jallad B, Vorugu V, et al. Lethal isotherms of cryoablation in a phantom study: effects of heat load, probe size, and number. J Vasc Interv Radiol 2009; 20: 1343-51.
24. Lee SJ, Choyke LT, Locklin JK, et al. Use of hydrodissection to prevent nerve and muscular damage during radiofrequency ablation of kidney tumors. J Vasc Interv Radiol 2006; 17: 1967-9.

Received: 30.04.2021, **accepted:** 25.05.2021.