Clinical Research

Computed Tomography-guided Percutaneous Bilateral Neurolytic Celiac Plexus Block with Alcohol for Upper Abdominal Visceral Cancer Pain

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Background: The neurolytic celiac plexus block (NCPB) can be introduced through the posterior para-aortic, anterior para-aortic, posterior transaortic, or endoscopic anterior para-aortic puncture approach, as well as the posterior approach via the intervertebral disc. To reduce the complications of puncture, this block's original manual blind puncture technique can be improved upon by using a C-arm fluoroscope, computed tomography (CT), or an ultrasound, the last of which may be endoscopic.

Objective: To observe the distribution of absolute alcohol and its analgesic effect on cancer-induced upper abdominal visceral pain during percutaneous NCPB through the anterior and posterior diaphragmatic crura under CT guidance.

Study Design: Clinical research study.

Setting: Department of Anesthesiology and Pain Medical Center, Jiaxing, People's Republic of China.

Methods: Thirty-eight patients (19 men and 19 women) with advanced carcinomatous epigastric pain were enrolled in this study. The patients were 47–88 (mean, SD: 64.9 ± 8.8) years old, weighed 37–62 kg (mean, SD: 51.6 ± 12.3), and had a grade III or IV physical status on the classification system established by the American Society of Anesthesiologists. The left and right punctures were made through the T12–L1 intervertebral space under CT guidance. The left side was punctured through the paravertebral and diaphragmatic crura to the anterolateral side of the anterior abdominal aorta of the diaphragmatic crus; and the right side was punctured via the posterior approach through the intervertebral disc to the posterior abdominal aorta of the diaphragmatic crus and then to the exterior. A solution consisting of 8 mL of 1% lidocaine and 1 mL of 30% iohexol was injected. If this injectate wholly or partly surrounded the abdominal aorta, then injecting anhydrous alcohol was deemed practicable. Fifteen mL of absolute alcohol containing 10 mL iohexol were injected into the left and right sides 15 minutes later. The alcohol diffusion was observed by CT. The pain Visual Analog Scale was used to evaluate the analgesic effect before NCPB and one hour, one week, one month, 3 months, and 6 months after the treatment. Any treatment-related complications were recorded.

Results: All patients were punctured at the predetermined position under CT guidance. Among the 23 patients whose injection of absolute alcohol surrounded the abdominal aorta completely, 19 (82.6%) stopped taking analgesic drugs altogether; of the 8 patients whose injection of absolute alcohol surrounded 75% of the abdominal aorta, 6 (75%) stopped taking oxycodone. In the 7 patients whose injection of absolute alcohol surrounded only 50% of the abdominal aorta, the pain was alleviated to varying degrees, but only 2 (28.6%) stopped taking oxycodone completely, and the other 5 patients still needed oral oxycodone. No abdominal bleeding, abdominal infection, or paraplegia occurred.

Limitations: The results of this study require further research with more clinical data to confirm them. The main limitation is the small sample size and the lack of a double-blind controlled comparison between the intragastric and extragastric injection administration method.

Conclusion: An NCPB that uses CT-guided double-needle puncture through the anterior and posterior diaphragmatic crura can improve absolute alcohol's ability to surround the corresponding segment of the abdominal aorta and block the greater and lesser splanchnic nerves and celiac plexus when injected. This approach to the NCPB has a better analgesic effect on patients with intractable visceral cancer pain in the upper abdominal area.

Key words: Neurolytic celiac plexus block, upper abdominal visceral cancer pain, computed tomography-guided

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Since 1914, when Kappis (1) and others first reported the percutaneous neurolytic celiac plexus block (NCPB), the technique has been recognized as an effective method for treating upper abdominal visceral pain. After several improvements, the present puncture approaches of NCPB include a posterior para-aortic approach, an anterior para-aortic approach, a posterior transaortic approach, a posterior approach via an intervertebral disc, and an endoscopic anterior para-aortic approach (2,3). To reduce the complications of puncture, the operation was also improved from the original manual blind puncture through the developments of x-ray, computed tomography (CT), ultrasound, and endoscopic ultrasound (4-7).

The CT-guided operation is the safest, most intuitive method (8,9). Our study reports 38 patients with upper abdominal pain due to a malignancy. Our NCPB procedure used a CT-guided posterior approach to the anterior and posterior diaphragmatic crura..

Methods

Ethics Statement

This retrospective study was approved by the institutional review board at our center (LS2018-141).

Patients

From January 2020 through December 2021, 38 patients with advanced cancerous upper abdominal visceral pain who received an NCPB treatment in the pain department of Affiliated Hospital of Jiaxing University were analyzed retrospectively, including 19 men and 19 women, aged 47–88 (mean, SD: 64.9 ± 8.8) years and weighing 37–62 kg (mean, SD: 51.6 ± 12.3).

Among the patients, 28 cases of advanced liver cancer recurred after surgery. There were 4 cases of postoperative liver metastasis from cholangiocarcinoma, one case of duodenal tumor, one case of liver metastasis of the duodenal tumor, 2 cases of colon cancer metastasis, one case of abdominal metastasis of gastric cancer, and one case of retroperitoneal sarcoma. Before the NCPB, all patients received the World Health Organization's 3-step oral analgesic ladder treatment. Twenty-one of those patients reached an oxycodone dose of 200 mg/d (the clinical practice guidelines for cancer pain in China allows oral medication dosages of this level) but still experienced a poor effect; 8 patients were unable to tolerate the vomit-inducing side effects of oral analgesics and were treated with NCPB; the other 9 patients received NCPB treatments after health education.

Indications

Platelets, coagulation time, and prothrombin time were normal before the procedure; there was no skin infection at the puncture site.

Contraindications

Patients were contraindicated for NCPB if they had massive ascites, heart failure or respiratory failure, an inability to lie prone for more than a few minutes, an allergy to alcohol or iodine, or metastasis in the body wall or bones. The characteristics of the operation, the expected analgesic effect, and the possible complications of NCPB were explained to the patients' families in detail. Informed consent forms were signed. Puncture instruments, drugs and monitors, oxygen, endotracheal intubation, simple breathing apparatuses and other rescue equipment were provided. The pain score on the Numeric Rating Scale (NRS) (0 as painless, 10 as the most painful) was recorded. A test for allergic reactions to the contrast medium (iodine) was carried out.

A indwelling cubital venous catheter was used to open the infusion channel. Patients fasted for 4 hours prior to the procedure. The patients with poor constitutions and low blood pressure were given a fluid infusion before the procedure began.

The patient entered the CT room while being infused with lactated ringer's solution. The patient was placed prone on the CT table. A nasal tube was inserted for oxygen. A monitor for blood pressure was used, as were an electrocardiogram and finger pulse oximeter.

A soft pillow was placed under the patient's abdomen. Spinous process was palpated for localization, and

a positioning grid was placed on either side above the corresponding thoracic 12 spinal processes at its heel. The T12–L1 intervertebral space was found through CT, and the T12 and L1 vertebrae were scanned in spinal mode. Those scanned images were then replayed. The level of the T12–L1 intervertebral space was selected as the puncture level, at which the puncture path was then designed.

A posterior approach was used to puncture the anterior abdominal aorta of the paravertebral diaphragmatic crus on the left side; the target was located at the anterolateral abdominal aorta. On the right side, a posterior approach was used to puncture the posterior abdominal aorta of the diaphragmatic crus of the intervertebral disc. A CT tool ruler was used to draw a straight line from the puncture target to avoid the vertebral body and abdominal organs.

The intersection of the straight line and the skin was set as the puncture point, and the puncture depth (the distance from the target point to the skin puncture point) and the angle (the angle between the line and the sagittal plane) were measured and recorded on both sides (Fig. 1). The distance was measured between the CT bed and the mark frame. The positioning CT red line was opened and the puncture plane ensured, and each puncture point on the positioning red line was marked according to the positioning grid (Fig. 2). After local anesthesia with 2% lidocaine, the needle was punctured to the target point under CT according to the proposed angle and depth.

Eight mL of 1% lidocaine containing one mL of 30% iohexol was then injected into both sides. The CT scan showed that the injected liquid tended to converge (the injected liquid on both sides converged anterior and posterior to the abdominal aorta) (Fig. 3) or that the abdominal aorta was basically surrounded (Fig. 4). Then, 15 mL of absolute alcohol containing 10 mL of the contrast medium iohexol were injected into the left and right sides.

Measurements of blood pressure, heart rate, and pulse oxygen saturation before the procedure and at 15 minutes, 30 minutes, one hour, and 2 hours afterward were taken. NRS scores were recorded before the procedure and at one hour, 24 hours, one week and one, 3, and 6 months after the procedure. If the NRS score was still above 4 points, oral oxycodone was administered and the dosage recorded.

SPSS Version 18.0 (SPSS, Inc.) statistical software was used for statistical processing. The measurement data are expressed as mean ± SD. An analysis of vari-

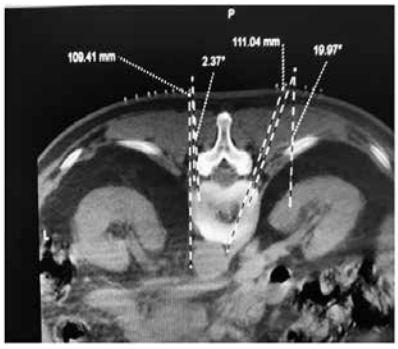

Fig. 1. *Design of double needle puncture path for anterior and posterior diaphragmatic crus through posterior approach (left puncture target is anterior lateral edge of abdominal aorta in front of diaphragmatic crus, penetrating diaphragmatic crus through paravertebral, depth of 10.47cm, angle of 2.37; right puncture target is posterior lateral margin of abdominal aorta of diaphragmatic crus, cervical intervertebral disc, depth of 11.1cm, angle of 19.97)*

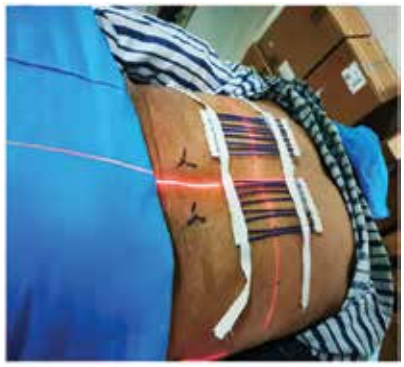

Fig. 2. *The needle insertion point was marked with the positioning grid on the back skin*

Fig. 3. *The contrast agent injected after the puncture reached the target point tended to merge around the abdominal aorta*

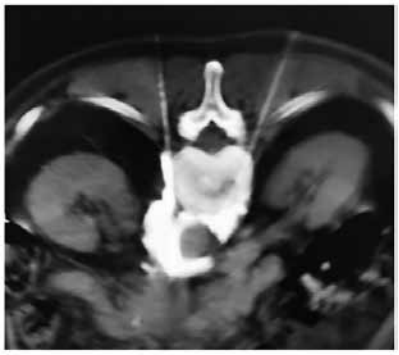

Fig. 4. *The local anesthetic solution containing contrast agent basically converged around the abdominal aorta*

ance of repeated measurement data was used to compare the indexes before and after the NCPB. $P < 0.05$ means that the difference is statistically significant.

Results

All 38 patients were successfully punctured under CT guidance. The distances were 11.28 ± 0.98 cm and 10.66 ± 0.92 cm, and the angles were 3.37° ± 1.19° and 13.23° ±1.47°, respectively. After 8 mL of 1% lidocaine were injected into both sides, 13 patients reported abdominal pain immediately after the injection of the absolute alcohol; the pain lasted for 20 minutes and was then relieved.

After the absolute alcohol injection, 23 patients (60.5%) had completely surrounded abdominal aortas. In addition, 8 patients had more than three-fourths of the abdominal aorta surrounded. In 7 patients, the absolute alcohol was blocked by enlarged lymph nodes or metastases around the abdominal aorta; as a result, only about one-half of the abdominal aorta was surrounded.

Compared to the pre-NCPB score, the mean NRS score at each post-NCPB time point was significantly lower (Table 1). Three patients died within one–3 months, and 9 patients died within 3–6 months after the procedure. Nineteen patients (82.6%) of the 23 patients whose abdominal aorta was completely surrounded by absolute alcohol stopped taking extended-release oxycodone altogether. Among the 8 patients whose injection surrounded more than three-fourths of the abdominal aorta, 6 (75%) stopped taking extended-release oxycodone. Additionally, 7 patients whose abdominal aorta was only halfway surrounded experienced varying degrees of pain reduction. Of these 7, only 2 (28.6%) stopped taking extended-release oxycodone completely; the other 5 still needed extended-release oral oxycodone.

Post-NCPB, patients' blood oxygen was higher than it was pre-NCPB. Compared to the pre-NCPB measurements, blood pressure decreased and heart rate increased at 15 minutes and 30 minutes after the NCPB. The blood pressure of 7 patients (18.4%) was 70% lower than it was before the NCPB. After rapid rehydration (average rehydration of 1,000 mL within 2 hours after the procedure) and ephedrine application, the patients recovered. On the day after the NCPB, 9 patients (23.6%) experienced diarrhea, which resolved after 36 hours. No abdominal bleeding, abdominal infection, or paraplegia occurred.

Discussion

NCPB puncture is more accurate with CT guidance than without it, and the puncture path can be planned and designed, making CT the best choice for guiding an NCPB procedure.

The neurolytic celiac plexus block is a recognized method for treating visceral abdominal pain caused by a malignant tumor. At present, the NCPB's accuracy and safety have been improved from the original manual blind probing puncture procedure through the use of a variety of imaging guidance technologies (4-7), such as x-ray, CT, ultrasound, and even magnetic resonance imaging.

In terms of imaging quality and guidance effect, a CT-guided procedure is the best choice. Unlike ultrasound, CT cannot be operated in real time; however, its image quality is clear and stable. CT can clearly display the abdominal aorta, inferior vena cava, diaphragm, and adjacent vertebral body around the abdominal aorta, as well as the kidney, pancreas, gastrointestinal tract, and other visceral organs. In addition, CT is useful for planning and designing the puncture path. The point, target, depth, and angle of the puncture can be determined before it takes place; scanning and correction can be conducted again during the puncture process to ensure that the puncture needle is delivered to the target accurately.

However, x-rays can only provide the position relationship between the puncture needle and the vertebral body or its appendages. X-rays cannot distinguish the relationship between the puncture needle and the viscera. Ultrasound images are easy to obtain; however, if the image is unstable and easily changes when the probe moves, and the image clarity and interpretability are weaker than those provided through CT, the operator should have professional training in the recognition of ultrasonic images. Furthermore, the operation

Table 1. *Numeric rating scale (NRS) before and after NCPB*

Time point	Preoperative	1 h (n = 38)	1w (n = 38)	1M (n = 38)	3M (n = 35)	6M (n = 27)
All patients	6.71 ± 0.96	2.63 ± 1.10	3.18 ± 1.27	3.55 ± 1.37	3.57 ± 1.22	3.77 ± 1.15
A	6.83 ± 0.98	2.39 ± 0.84	2.96 ± 1.07	3.17 ± 1.15	3.38 ± 1.28	3.59 ± 1.06
B	6.50 ± 0.93	2.25 ± 0.71	2.63 ± 0.74	3.25 ± 0.89	3.38 ± 0.74	3.67 ± 1.03
C	6.57 ± 0.98	3.85 ± 1.46	4.57 ± 1.51	5.14 ± 1.46	4.50 ± 1.22	4.75 ± 1.50

All patients F/P	F_{total} = 111.71/*P* total < 0.001
Time point F/P	49.19/< 0.01
Between groups F/P	5.792/0.009
Time point*	
Between groups F/P	1.29/0.243

Note: A: patients whose abdominal aorta was completely surrounded by absolute alcohol; B: patients whose abdominal aorta was surrounded 3/4 by absolute alcohol; C: patients whose abdominal aorta was surrounded 1/2 by absolute alcohol.
The results of repeated measures analysis of variance showed that there were statistically significant differences in pain visual analog scores at different time points in the total population, and the NRS scores at each time point after NCPB were significantly lower in all patients than before NCPB ($P < 0.01$).
There was no significant difference in the interaction between time and groups (P=0.243). The NRS score of the group with 100% anhydrous alcohol encapsulation was significantly lower than that of the groups with 75% and 50% encapsulation. The NRS scores of the three groups before surgery were not statistically significant ($P > 0.05$), but the NRS scores at each time point after surgery showed an upward trend, and the difference was statistically significant ($P < 0.01$).

should not be guided by magnetic resonance imaging. The puncture needles and related equipment needed for magnetic resonance imaging have high requirements that make them impracticable for the procedure. Moreover, if iohexol is added to the injected solution of absolute alcohol, the distribution of said solution can be observed clearly under CT (8). Therefore, many surgeons believe that CT is the best choice for guiding NCPB procedures (9,10).

A double-needle puncture in front of and behind the diaphragmatic crus is an easy approach for inducing the injected medicinal solution so that it surrounds the abdominal aorta and block the celiac plexus and splanchnic nerves simultaneously, thus achieving a better analgesic effect.

The greater splanchnic nerve at T5–T9 and the small splanchnic nerve at T10–T12, which originate from the T5–T12 spinal cord segments, descend anterolaterally along the corresponding vertebral body. These nerves enter the abdominal cavity through the esophageal hiatus of the diaphragm. The left and right celiac ganglia are formed on both sides of the celiac trunk and superior mesenteric artery from the T12–L1 intervertebral space to the upper level of the L1 vertebral body. Postganglionic nerve fibers form the celiac nerve plexus.

The celiac plexus is distributed in the fat layer on both sides of the abdominal aorta, wraps around the celiac trunk and the root of the superior mesenteric artery, and distributes to the abdominal organs along with the artery. In other words, the preganglionic fibers of the celiac plexus are located in the anterolateral thoracic vertebrae behind the diaphragmatic crus, while the retroganglionic celiac plexus is located around the artery in front of the diaphragmatic crus.

The NCPB achieves a perfect blocking effect; the injected nerve-destroying drug surrounds the abdominal aorta and the root of the celiac trunk and superior mesenteric artery at the level of the T12–L1 vertebral body, effectively destroying the nerve fibers of the celiac plexus and thereby interrupting the pain sensation reflex arc.

De Cicco et al (11) found that if the abdominal aorta is taken as the center, the abdominal cross-section can be divided into 4 areas: upper left, upper right, lower left, and lower right. If the injected absolute alcohol can diffuse to all 4 areas, the long-term analgesic effect (effective analgesia for more than one month) can reach 100%. If only one or 2 areas are diffused, no long-term analgesic effect is achieved.

The corresponding region of the diaphragmatic foot is a natural barrier to absolute alcohol distribution (3). It is difficult for the absolute alcohol injected before the diaphragm foot to enter the hind part of the diaphragmatic crus. Therefore, it is easier to wrap the abdominal aorta with the injected absolute alcohol by double needle puncture in front of and behind the diaphragmatic crus, thus possibly achieving full coverage of the 4 areas around the abdominal aorta. In this way, in addition to the achievement of this complete coverage, the retroganglionic celiac plexus in front of the diaphragmatic crus and its preganglionic fibers (the

large and small visceral nerves) behind the diaphragmatic crus will be destructively blocked, thereby creating a better analgesic effect (12). There is no need to limit the double needle puncture in front of the left diaphragmatic crus and behind the right diaphragmatic crus described in this paper. The double needle puncture can also lead to the wrapping of the corresponding segment of the abdominal aorta, a desirable result (Figs. 5-8).

Advanced neoplastic abdominal pain is often accompanied by para-aortic lymph node metastasis and enlargement. Some enlarged lymph nodes are fused into a mass and close to the abdominal aorta. These metastatic lymph nodes block the spread of the injected absolute alcohol, also commonly cause the injected absolute alcohol to wrap around the abdominal aorta, and are an independent factor affecting the efficacy of the NCPB (13). The needle can be punctured into the metastatic foci for injection, and the absolute alcohol can flow to the relatively loose tumor space under strong injection, resulting in a certain antitumor effect.

Among our study's patients, 23 of the 38 achieved a complete encircling of the abdominal aorta; the analgesic effect was ideal. Nineteen of these patients were able to stop taking extended-release oxycodone completely; only 4 patients still needed extended-release oral oxycodone maintenance after surgery.

According to the medication history for the patients who needed oxycodone preoperative, their extended-release oxycodone dosage was more than 200 mg/d, for more than 4 weeks. These patients were considered opioid dependent. Among the 7 patients whose injection surrounded only one-half of the abdominal aorta, 5 of them needed different doses of extended-release oral oxycodone to maintain an analgesic effect. The different degrees to which the abdominal aorta was

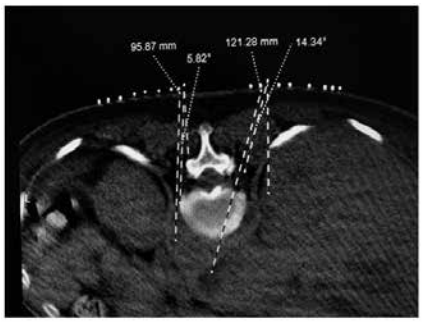

Fig. 5. *Design of double needle puncture path for anterior and posterior diaphragmatic crus through posterior approach (the right puncture target is the anterolateral edge of abdominal aorta in front of diaphragmatic crus, which penetrates the diaphragmatic crus through paravertebral, with a depth of 12.1cm and an angle of 14.34°; The left puncture target is the posterolateral border of the abdominal aorta behind the diaphragmatic crus, with a depth of 9.59cm and an angle of 5.82°*

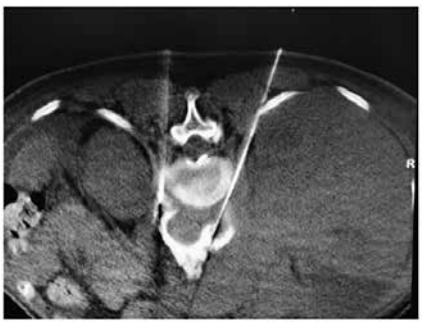

Fig. 7. *The abdominal aorta is surrounded by a convergence after local anesthetic injection*

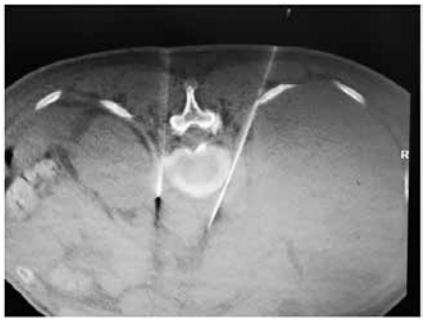

Fig. 6. *CT guided puncture to the target according to the designed path*

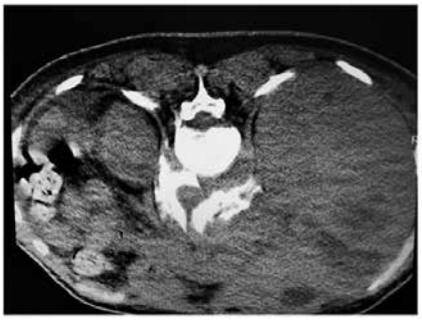

Fig. 8. *The abdominal aorta is surrounded by absolute alcohol*

wrapped by the absolute alcohol during the NCPB constituted a statistically significant difference. A sufficient volume of absolute alcohol on both sides was required for the total encircling of the abdominal aorta.

Although 8 mL of 1% lidocaine were injected via 2 needles, only 9 patients who received this injectate experienced the complete wrapping of the abdominal aorta (23.7%), whereas 23 patients (60.5%) who received absolute alcohol at volumes of 10 mL or 15 mL achieved abdominal aortal wrapping. These results indicate that the quality of the NCPB depends on the volume of absolute alcohol.

A diagnostic block of local anesthetics and a contrast medium before the injection of absolute alcohol can not only reduce the burning pain that the alcohol causes to the abdominal cavity but also allow for the prediction of the general distribution of the absolute alcohol injection. The distribution of the local anesthetic solution may predict the curative effect and complications of the NCPB.

Yuen et al (14) found that the sensitivity and specificity of a diagnostic celiac plexus block before the administering of an NCPB were 93% and 37%, respectively. The positive predictive value was 85%, and the negative predictive value was 58%. The clinical effect of NCPB has been considered questionable and possibly unnecessary for patients with advanced malignant tumors. However, we believe that before the physician injects absolute alcohol for an NCPB, lidocaine and a contrast medium should be injected to prevent the burning pain caused by absolute alcohol and to merge with the absolute alcohol that diffuses both inside and outside the diaphragmatic crus and on the left and right sides of the abdominal aorta according to the CT scan (Fig. 2) or converges to wrap around the abdominal aorta (Fig. 3). This combined injection of lidocaine and a contrast medium can predict whether the injection of absolute alcohol will merge and surround the abdominal aorta (Figs. 4 and 9).

Critical predictions can be based on whether lidocaine enters the vascular system and flows away. If absolute alcohol is injected at this time, it will cause an embolism and even infarction of important organs. If absolute alcohol enters the spinal root artery, it will infarct the spinal cord and cause paraplegia; if the lidocaine is found to be deposited into the diaphragmatic crus or in the back of the anterior longitudinal ligament and distributed along the vertebral body toward the intervertebral foramen, then the needle tip position should be adjusted to prevent postoperative deep

Fig. 9. *The abdominal aorta was completely surrounded by absolute alcohol containing contrast agent*

breathing pain or the entrance of absolute alcohol into the intervertebral foramen canal, which can cause corresponding movement disorders or paraplegia.

In previous reports of paraplegia, it was suggested that injecting absolute alcohol might cause a spinal artery spasm (15-18). Moreover, Moore (4) believed that if NCPB was performed under the guidance of C-arm x-ray, the risk of paraplegia could not be eliminated because the details of the distribution of absolute alcohol could not be seen clearly.

To prevent the complications of abdominal infection, the posterior approach should be adopted first. When the patient is punctured through the posterior approach while prone, the puncture needle is passed through the back muscle fascia or intervertebral disc and other sterile tissues and organs (3,10,19). The risk of infection is low, even if the patient cannot move while prone for various reasons. The posterior approach puncture can be performed with the patient in the lateral decubitus position.

When the anterior approach is used, regardless of whether it is guided by CT or endoscopic ultrasound, the puncture needle may pass through the hollow organs, such as the gastrointestinal tract, and thereby come into contact with bacteria. In addition, patients with advanced tumors are mostly in a weak immune state and are susceptible to abdominal infection and other complications.

All of our patients were punctured by the posterior approach. No abdominal infections occurred. The patients' blood pressure decreased, and their heart rates increased by 18.4% after the NCPB. It was considered that the blood volume was relatively insufficient due to visceral vasodilation after the sympathetic nerve block. Therefore, a certain amount of fluid load should be given before and during the operation, and patients'

circulation must be monitored. If necessary, an appropriate amount of vasoconstrictor drugs should be used to maintain circulation stability. Transient diarrhea after the NCPB was common (23.6%). This temporary ailment is also considered to be caused by the relative hyperactivity of vagus nerve function after a sympathetic nerve block, which leads to an increase of gastrointestinal peristalsis. Diarrhea is mostly resolved within 2 to 4 days after the autonomic function rebalances and rarely develops into intractable diarrhea, which generally does not require special treatment. If serious abdominal dysfunction occurs, octreotide may be effective in stopping diarrhea (20).

Limitations

Further research that incorporates a greater range of clinical data is needed to confirm our results. The main limitation is the small sample size and the lack of a double-blind controlled comparison between the intragastric and extragastric injection administration method.

Conclusions

A CT-guided NCPB that uses a double needle to puncture the anterior and posterior diaphragmatic crura can improve the convergence of injected absolute alcohol and its ability to wrap around the corresponding segment of abdominal aorta. Done in this way, the procedure can also block the greater and lesser splanchnic nerves and celiac plexus at simultaneously and produce a better analgesic effect for patients with intractable upper abdominal cancer pain.

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