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De Novo coupled use of central-vein isolation and tubeless treatment in laparoscopic adrenalectomy

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ABSTRACT

Objective: To explore the combined uses of central vein isolation-based laparoscopic technique and tubeless cardiovascular interventional technique (CVIT) in laparoscopic adrenalectomy.
Methods: 31 subject patients with adrenal tumors were recruited and treated from January 2020 to November 2021. Regarding tumor size, the average transverse diameter of the adrenal tumor was (2.2 ± 1.0) cm and the average longitudinal diameter of the tumor was (3.1 ± 1.5) cm, respectively. All subject patients were operated on through the abdominal approach. The "central vein isolation" based laparoscopic technique was adopted to complete the operation. No drainage tube was placed in the patients. For this study, selected performance parameters, including the operation time, intraoperative bleeding, postoperative hospital stays, and postoperative complications were recorded and analyzed.
Results: All the tumors were removed laparoscopically without any conversion to open surgery. All 31 recruited subjects were treated successfully with preservation of adrenocortical function. The mean operation time was 30 min (range from 25 to 63 min); the mean amount of intraoperative bleeding was approximately 3 mL (ranges from 0 to 10 mL); the mean postoperative hospital stay was 3 days (range from 2 to 6 days). Of note, no complications were recorded, such as adjacent organ injury, large vessel injury, infection, and secondary bleeding that occurred during and after the operation.
Conclusion: The combined use of central-vein isolation laparoscopic technique and tubeless treatment ensures a facile, safe, and robust laparoscopic adrenalectomy operation in clinical practice.

1. Introduction

Adrenal tumors include various pathological entities that vary widely from benign non-functioning cortical adenoma to adrenocortical carcinoma. Currently, the surgical approach remains the first-line treatment method for patients with adrenal tumors [1–3]. There have been marked advances in the surgical protocols adopted for adrenalectomy during the last few decades. Since the pioneering work reported by Michel Gagner and associates in 1992, laparoscopic adrenalectomy has now become the standard technique for the surgical treatment of many adrenal diseases considering its advantageous traits, including alleviated postoperative pain, reduced morbidity, and shorter recovery time [4–7].

Compared with the conventional open adrenalectomy strategies, laparoscopic adrenalectomy provides improved feasibility, safeness, effectiveness, and minimized morbidity [8,9]. Considering the operation protocols, the laparoscopic adrenalectomy can further be divided into two groups, namely the retroperitoneal approach and the abdominal approach [10–12]. As of now, retroperitoneal-based approaches have been widely adopted for laparoscopic adrenalectomy. Meanwhile, significant advancements in surgical techniques further contribute to the development of the other types of laparoscopic adrenalectomy operation scheme- the abdominal approach. The abdominal approach has been increasingly used for suprarenal gland tumor resection, particularly in

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inpatient cases with large-sized tumors [13–16].

Even though laparoscopic adrenalectomy has emerged as a critical role in adrenal tumor treatments, it is still challenging to meet the requirements of precision surgery, a more tailored approach for the precise management of patients undergoing operations [17,18]. Attempting to achieve precision surgery for adrenal tumors patients, we here propose the *De Novo* coupled uses of central-vein isolation laparoscopic technique and tubeless treatment in laparoscopic adrenalectomy. In this study, 31 patients with adrenal tumors recruited from January 2020 to November 2021 were grouped and treated with our designed new operation protocols. The results show that our approach warrants a facile, safe, and robust laparoscopic adrenalectomy operation in comparison with the conventional counterpart methods, opening new trials for the realization of precision surgery in urological patients.

2. Patient subjects and methods

2.1. Study design and participants

We here present a single-center retrospective study conducted between January 2020 and November 2021. All patients have given their informed consent for participation in the research study. Upon the patient's admission to the hospital, a full routine preoperative examination of an endocrine hormone, including blood and urine catecholamine, cortisol rhythm, aldosterone, and electrolyte, was performed to determine the tumors.

For our study, 31 patient subjects were recruited and operated on with the CVIT procedure, including 15 cases on the left and 16 cases on the right, all of which were unilateral lesions. All operations were carried out by the two same experienced urologists. The mean age of the patients was (49.0 $\pm$ 11.5) years old, with a male-to-female ratio of around 1.2:1. The dimensional size of tumors was initially evaluated by the routine B-ultrasound (B Flow Ultrasound, GE Healthcare) before the laparoscopic operation: the mean transverse diameter of the tumor was (2.2 $\pm$ 1.0) cm, and the average longitudinal diameter of the tumor was (3.1 $\pm$ 1.5) cm, respectively. For further examination, the size of the adrenal tumor sample was measured and classified by computed tomography (CT, LightSpeed VCT, GE Healthcare).

All adrenal tumor samples of recruited subjects were classified as benign types, with a Weiss score of 0 or 1. Additional postoperative pathological diagnosis provides a glimpse into the assortment of tumor types: Among recruited 31 cases, 23 cases were nonfunctional cortical adenoma, 2 cases were lipoma, 2 cases were ganglion, 1 case was pheochromocytoma, 1 case was hypercortisolism, 1 case was a dermoid cyst and 1 case was a fibroma (See Table 1). Preoperative and perioperative preparation was performed according to the nature of the tumor.

Table 1
Baseline characteristics of patients.

Characteristics	Value
Total recruited patients	31
Male	17
Female	14
Covid-19 Positive case	0
Covid-19 Negative case	31 (100%)
Averaged age	49.0 $\pm$ 11.5 (37–61)
CVIT operation -Left side case	15
CVIT operation -Right side case	16
Tumor size-mean transverse diameter (cm)	2.2 $\pm$ 1.0
Tumor size-mean longitudinal diameter (cm)	3.1 $\pm$ 1.5
Malignancy of adrenal tumors	
Benign	31 (100%)
Malignant	0
Pathological diagnosis	
Nonfunctional cortical adenoma case	23 (74.2%)
Lipoma	2 (6.45%)
Ganglion	2 (6.45%)
Pheochromocytoma	1 (3.23%)
Hypercortisolism	1 (3.23%)
Dermoid cyst	1 (3.23%)
Fibroma	1 (3.23%)

As this study was carried out amid the Covid-19 pandemic, Covid-19 was tested for each subject when admitted to the hospital. All recruited subjects are all tested Covid-19 negative (PCR testing kits) and have not been diagnosed with Covid-19 previously. The study protocol and the informed consent form were both approved by the Ethics Committee of the Hospital (CR20200865). This study is conducted by the Declaration of Helsinki, National Diagnosis and Treatment of Urological Diseases Guidelines (CUA guidelines), EUA guidelines, and AUA guidelines.

2.2. Surgical methods

Step 1: Establish the operation space

After general anesthesia, patients were treated by taking a fully healthy lateral position and sequentially raising the waist to establish the pneumoperitoneum. To start with, a 12 mm trocar was placed under the coastal edge of the middle clavicular line, a 10 mm trocar at the outer edge of the rectus abdominis, and another 12 mm trocar was placed on the upper part of the iliac crest at the axillary front. Meanwhile, a 5 mm trocar was placed under the xiphoid process for auxiliary liver blocking.

Step 2: Free the colonic mesangium

Left side: Cutting the side peritoneum along the toldt line of the descending para-colonic sulcus to separate the anterior layer of Gerota fascia and the colonic fusion fascia space and push the colon and its mesangium inward (Figs. 1**a** and 1**b**).

Right side: Cut off the right triangular ligament of the liver, subsequentially lift the liver with a needle holder, and cut the hepatosplenic ligament horizontally 1 cm along the lower end of the liver to the inferior vena cava. Dissociation along the lower end of the right lobe of the liver exposed the upper pole of the kidney and dissociated the lower part of the adrenal gland. Then cut part of the colonic fusion fascia and pushed to open the duodenum (Figs. 1**c** and 1**d**).

Step 3: Free the adrenal higher plane

Left side: Extend the peritoneal lateral incision to the spleen. Cut the spleen diaphragmatic ligament, spleen and colon ligaments, spleen and kidney, to fully free ligament between spleen and kidney tissue, and to extend on the plane (Fig. 2**a**).

Right side: Along the bottom of the right hepatic lobe and the adrenal glands, free the extension plane between the superiors, until seeing the diaphragm that is medial to the inferior vena cava (Fig. 2**b**).

Step 4: Free the upper pole of the kidney

Free the avascular plane between the adrenal gland and the upper pole of the kidney, until the diaphragm could be observed. (Figs. 2**c** and 2**d**).

Step 5: Free the back plane of the adrenal

Free the backplane of the adrenal behind the adrenal gland and diaphragm (Figs. 3**a** and 3**b**).

Step 6: Cut off the isolated central vein

Clip the isolated central vein with 1–2 Hem-o-lock clips (Figs. 3**c** and 3**d**).

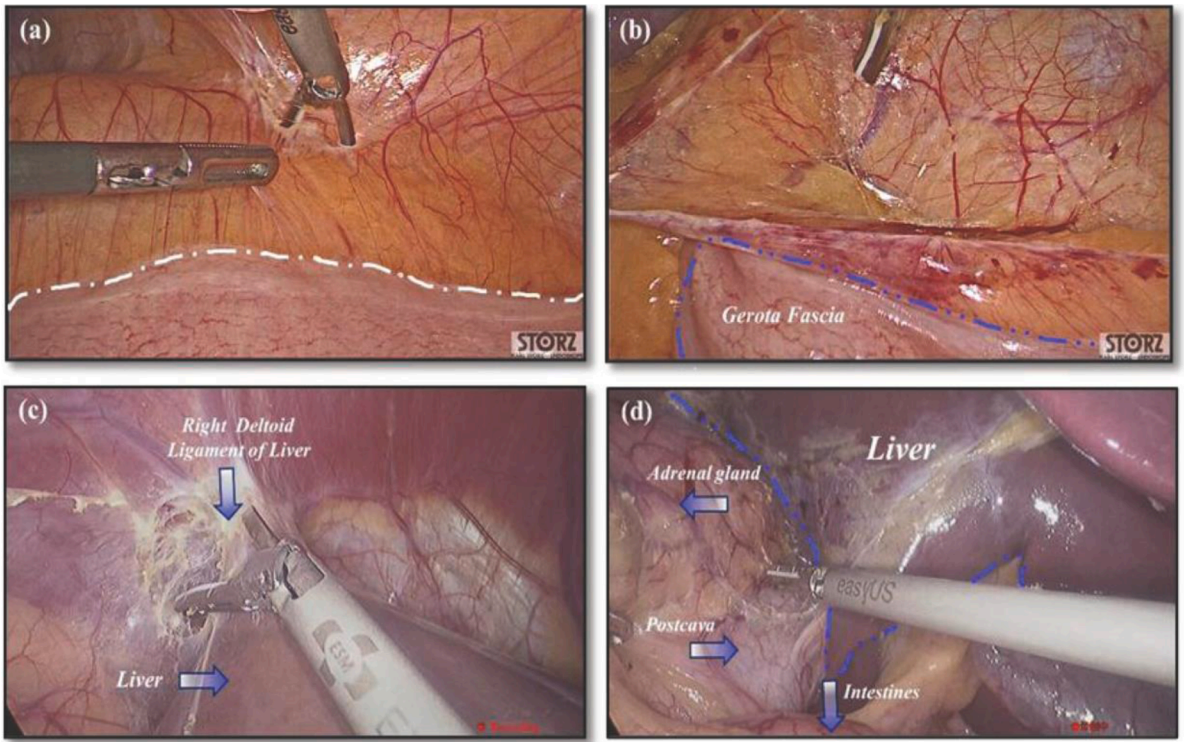

Fig. 1. Resection of the left adrenal tumor and the right adrenal tumor using CVIT procedure. (a) Incision of the lateral peritoneum along the toldt line. (b) Separation of the anterior layer of the Gerota fascia and the colonic fusion fascia gap. (c) Cutting off the liver's right deltoid ligament. (d) Free the liver colon ligament, and expose the inferior vena V and the renal upper area.

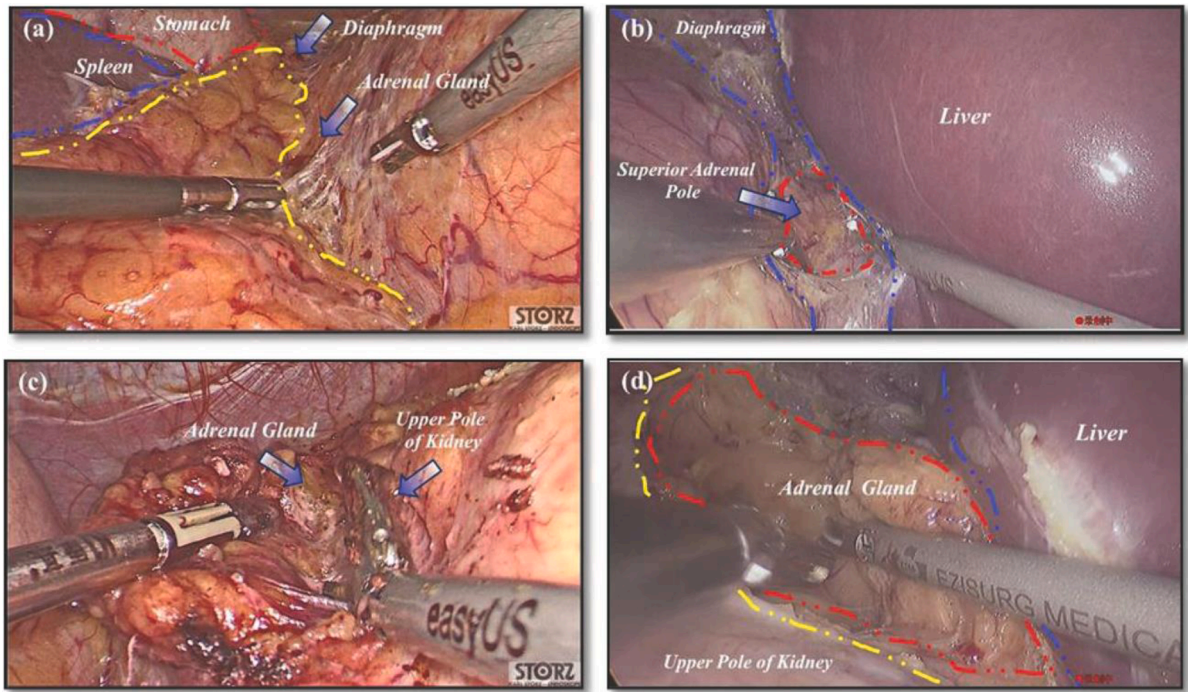

Fig. 2. Free the adrenal higher plane and the upper pole of the kidney *via* CVIT procedure. (a) Free the left adrenal gland higher plane. (b) Free the right adrenal higher plane. (c) Free the left renal upper plane. (d) Free the right renal upper plane.

2.3. Performance indicators

To fully evaluate our proposed *de novo* coupled uses of central-vein isolation laparoscopic technique and tubeless treatment in laparoscopic adrenalectomy, we recorded and analyzed a series of selected indicating parameters, including patients' operation time, intraoperative blood loss, postoperative hospital stays, postoperative complications, and other relevant follow-up results.

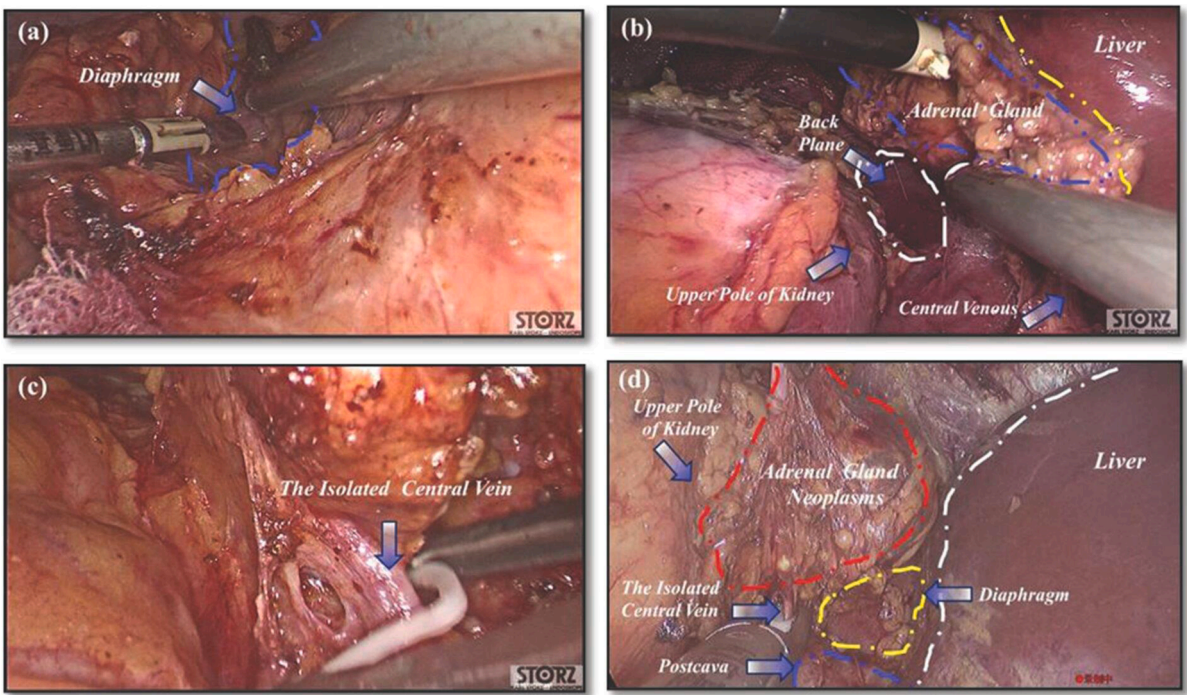

Fig. 3. Free the backplane of the adrenal and treat the isolated central vein *via* CVIT procedure. (a) Free the backplane of the left adrenal. (b) Free the backplane of the right adrenal. (c) Treat the left isolated central vein. (d) Treat the right isolated central vein.

2.4. Statistical analysis

All statistical analyses were performed using SPSS statistical software version 13.0 (SPSS, Inc, Chicago, IL). All continuous data were expressed as mean 6 standard deviations and were compared using the 2 independent samples Student *t*-test. All categorical data were expressed as numbers (%) and compared using Fisher's exact probability test. A P value less than 0.05 was considered statistically significant.

3. Results

All the tumors were removed laparoscopically without any conversion to open surgery. All 31 recruited subjects were operated with procedures that complied with the designated protocol and were treated successfully with preservation of adrenocortical function. The operation time ranges from 25 to 63 min, with a mean time of around 30 min; the amount of intraoperative bleeding ranges from 0 to 10 mL, with a mean value close to 3 mL; the postoperative hospital stays range from 2 to 6 days, with a mean stay near 3 days. Of note, no complications were recorded, such as adjacent organ injury, large vessel injury, infection, and secondary bleeding that occurred during and after the operation, see Table 2.

Compared with other studies with similar topics and protocols, our proposed strategy provides promisingly superior operational performance. For instance, in a study of 462 patients undergoing laparoscopic adrenalectomies by Gaujoux et al., complications – including medical complications and surgical complications- were reported as 14.6% [19]. In another conventional laparoscopic adrenalectomy study reported by Wang et al., 2 patients (2/23, 8.7%) were converted into open adrenalectomy and recorded **a** significantly higher amount of intraoperative bleeding (102 ± 57 mL) than that of our case (5 ± 5 mL) [20].

Table 2
Operative and postoperative characteristics of patients.

Parameters	Value
Operation time (mins)	25–63, mean: ~30
Intraoperative bleeding amount (mL)	0–10, mean: 3
Converted into open adrenalectomy (Case)	0
Postoperative hospital stay (Day)	2–6, mean: ~3
Complications	/
Adjacent organ injury (Case)	0
Large vessel injury (Case)	0
Infection (Case)	0
Secondary bleeding (Case)	0
Follow-up (months)	3–8, mean: 4.6
Recurrence (Case)	0

4. Discussion

Adrenal disease encompasses a wide spectrum of congenital and acquired conditions which could lead to adrenal hyperfunction or hypofunction [21,22]. Diseases of the adrenal gland occur rather more frequently than is appreciated and provide great challenges for the treating practitioner. Promisingly, the treatment of adrenal diseases has recently undergone remarkable development, owing to the rapid advances in implementing new surgical technique protocols. Among these operative procedures, laparoscopic adrenalectomy has garnered substantial attention among clinical endocrinologists as the procedure of choice for the resection of most adrenal tumors [23–25]. Compared with traditional open surgery techniques, these minimally invasive procedures warrant improved operation performance by providing shorter hospital stays, less postoperative pain, and more rapid convalescence. However, several issues remain controversial among the experts. For instance, in laparoscopic adrenalectomy one sacrifices the tactile sense and must manipulate the fragile adrenal gland with instruments in a two-dimensional plane. Such deficits largely prohibit the development of "precision surgery" platforms [26,27].

Following the paradigm of precision medicine, contemporary urologic surgery has entered a technology-driven era of "precision surgery", which entails a range of surgical procedures tailored to combine maximal treatment efficacy with minimal impact on patient function and health-related quality of life [17,22]. Striving to realize precision surgery for adrenal disease treatments, we herein propose a new laparoscopic technology paradigm by combining the implementations of the central vein isolation-based laparoscopic technique and the

postoperative tubeless treatment method.

During this operation procedure, the following points should be kept in mind to implement the concept of precision surgery in the whole process [28,29]:

I The level must be found accurately, and the separation level must be thorough.
II The operation actions should be as gentle as possible, especially in the process of isolating the central vein. Particular attention needed to be addressed to protect vital periphery blood vessels.
III The separation is required to be completed by the use of an attractor and ultrasonic knife.

The successful realization of coupled uses of central-vein isolation laparoscopic technique and tubeless treatment in laparoscopic adrenalectomy serves as the solid foundation for postoperative tubeless surgery [30–32]. In our study, patients treated with this laparoscopic adrenalectomy technique exhibited remarkable clinical effects: The surgical path-planning was optimized, and the postoperative treatment of adrenalectomy was improved *via* the intraperitoneal approach. The establishment of this new laparoscopic adrenalectomy holds great potential for the successful realization of precision surgery in urologic surgery, considering its advantageous qualities listed below:

I During the operation, three non-vascular planes were used for the preferential separation to avoid intraoperative bleeding and reduce the interference of retroperitoneal fat on the operation field and space.
II The final treatment of the isolated central vein during the operation can eliminate the possibility of accidental injury to the blood vessels in the process of searching the central vein in the early stage. Particularly for beginner surgeons, this can well alleviate the pressure of operation and ensure the safety of the operation.
III No tube treatment requirement after the operation could maximize the comfort experience of patients, shorten the hospitalization time, reduce the hospitalization expenses, and relieve the postoperative anxiety, fear, and other associated discomforts of patients.

Compared with the traditional laparoscopic adrenalectomy, including the extraperitoneal approach and the intraperitoneal approach, our proposed surgical protocol delivers clearer operation paths, wider operation space, and vision, a more explicit interpretation of anatomical markers, and displays the outline of the adrenal gland and/or tumors instantly, which well fits the psychological expectation of beginners and greatly improve the learnability of this surgical technique.

5. Conclusion

In conclusion, we proposed *De Novo* coupled uses of central-vein isolation laparoscopic technique and tubeless treatment in laparoscopic adrenalectomy. In this study, 31 recruited patients were treated with our proposed new laparoscopic adrenalectomy method. Study results showed that none was converted to open surgery, and no drainage tube was placed after the operation. All patients had not experienced any complications, such as adjacent organ injury, large vessel injury, infection, and secondary bleeding during and after the operation. These advantageous attributes are practically useful for beginners, hospitals, or institutes. Therefore, the combined use of central-vein isolation laparoscopic technique and tubeless treatment warrants a facile, safe, and robust laparoscopic adrenalectomy operation, holding great potential for health promotions in clinical application and clinical practice.

Author contributions

Study concept and design: Baisheng Xu, FenGui Leng, Bin Fu, Yanying Jiang, Feng Wang, Jianmiao Hu, Hongbing Gao, Xu Leng, Caizhi Liao. **Data acquisition**: Bai-sheng Xu, Fen-Gui Leng, Yan-ying Jiang. **Data analysis**: Bai-sheng Xu, Fen-Gui Leng, Yan-ying Jiang, Cai-zhi Liao. **Drafting of manuscript**: Bai-sheng Xu, Fen-Gui Leng, Cai-zhi Liao. **Critical revision of the manuscript**: Bai-sheng Xu, Cai-zhi Liao.

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.

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