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## **Current status and prospects of enhanced recovery after surgery combined with percutaneous nephrolithotomy in urology**

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### **Abstract**

Enhanced recovery after surgery (ERAS) refers to the use of a series of specific evidence-based and proven effective measures during the perioperative period to enable quick recovery of patients. It can reduce the physiological and psychological pressure of patients, reduce the occurrence of postoperative complications, thereby shortening the hospital stay and reducing hospitalization costs. Percutaneous nephrolithotomy is the main method for the treatment of renal calculi and upper ureteral calculi. It is widely used in clinic because of its small trauma, high stone clearance rate, short postoperative recovery time and short hospital stay. This article reviews the current status of ERAS combined with percutaneous nephrolithotomy in urology and the role of ERAS in percutaneous nephrolithotomy.

**Keywords:** enhanced recovery after surgery; percutaneous nephrolithotomy; preoperative period; urologic surgery

## 1. Introduction

Percutaneous nephrolithotomy (PCNL) has been widely used in clinic since it was first reported by fernstorm and Johansson in 1976 because of its advantages of small trauma, high stone removal rate and rapid postoperative recovery. The concept of enhanced recovery after surgery (ERAS) was proposed by Kehlet et al.<sup>[1]</sup> in 1999 and successfully applied in practice. Eras mainly includes the following three aspects: ① Preoperative education and evaluation. ② Optimization of anesthesia and application of minimally invasive surgery. ③ Postoperative rehabilitation measures include early eating, early activity and early removal of drainage tube<sup>[2]</sup>. The concept of eras is patient-centered, which is similar to PCNL. The combination of eras and PCNL should play a better role in clinical practice.

## 2. Application of percutaneous nephrolithotomy

Percutaneous nephrolithotomy refers to lithotripsy and lithotomy under nephroscope. At present, the European Association of Urology (EAU) guidelines recommend PCNL mainly for kidney stones larger than 2cm and lower calyceal stones larger than 1.5cm, and the American Urological Association (AUA) guidelines recommend PCNL for the treatment of staghorn kidney stones. It is easy to cause hemorrhage in the early stage of operation, especially in the renal parenchyma and around the kidney, which is easy to cause hemorrhage in the early stage of operation. In 1998, Li et al.<sup>[3]</sup> proposed a microchannel percutaneous nephrostomy with a puncture channel of 14 ~ 16 F, and used this channel for secondary PCNL. Later, Li<sup>[4]</sup> proposed a more simple and convenient minimally invasive surgical method of simultaneous puncture and lithotomy, which was gradually popularized and applied in China. However, the symptoms such as bleeding, fever and pain after PCNL cause serious postoperative psychological obstacles and limit the postoperative recovery of patients. The recently widely recognized era concept can significantly shorten the hospital stay, reduce postoperative complications and hospitalization expenses. The combination of era concept and PCNL should make up for the above deficiencies.

## 3. Perioperative management of eras

In recent years, in order to reduce patients' perioperative trauma stress and psychological pressure and accelerate postoperative rehabilitation, the traditional perioperative treatment mode has been constantly challenged, such as no preoperative intestinal preparation, avoiding long-term preoperative fasting, multimodal analgesia, early postoperative activities, early postoperative eating, etc. These measures are called perioperative safety measures. In the field of colorectal surgery, the ERAS principle has been proven to reduce incidence rate of postoperative morbidity and hospital stay<sup>[5]</sup>. At present, the application of eras in urology is relatively few in China. The perioperative application of eras is mainly divided into three stages: preoperative, intraoperative and postoperative.

### 3.1. Preoperative

Preoperative education the preoperative education of eras is to conduct psychological communication with patients and inform patients of the operation plan and the recovery plan of each stage. Adequate preoperative education can alleviate the patient's tension, fear and anxiety, enhance the confidence to overcome the disease, reduce the physiological stress response, and promote the patient's postoperative recovery. Clinical studies have confirmed that smoking can lead to decreased tissue oxygenation, postoperative mouth infection, pulmonary complications and deep venous thrombosis. Quitting smoking for 4 weeks before operation can significantly reduce the incidence of perioperative complications<sup>[6]</sup>.

The traditional concept of preoperative fasting and fasting believes that the preoperative fasting time of water should be as long as 10~12 hours, so as to reduce the risk of lung inhalation during anesthesia, and long-term fasting and fasting will cause thirst, hunger, anxiety and so on. At present, many studies have shown that it is safe to eat solid food 6 hours before operation and liquid food 2 hours before operation. Oral carbohydrate liquid diet 2 hours before anesthesia can supplement water and energy, improve the patient's tolerance to surgical trauma, promote the secretion of autologous insulin, reduce postoperative insulin resistance<sup>[7]</sup>, improve body surface temperature and reduce postoperative shivering<sup>[8]</sup>. In the eras consensus, oral

carbohydrate drinks 2 hours before operation are considered to be one of the most important reasons to shorten the length of hospital stay, which can accelerate the postoperative rehabilitation of patients<sup>[9]</sup>.

### 3.2. Intraoperative

Compared with open surgery, percutaneous nephrolithotomy has less trauma, but the impact of a large amount of high-pressure water will take away a lot of heat, the core body temperature decreases ( $\leq 36^\circ\text{C}$ ), and catecholamine and cortisol are released during rewarming, which increases the surgical stress response. Studies have confirmed that hypothermia will increase intraoperative bleeding, increase the incidence of cardiovascular and cerebrovascular accidents, cause postoperative shivering, increase oxygen consumption and postoperative wound infection<sup>[10]</sup>. Therefore, it is very important to keep the patient's normal temperature during operation. It is the key to reduce surgical stress and organ dysfunction. For patients with long operation time, preoperative use of carbohydrate drinks, mattress preheating, intraoperative central body temperature monitoring, heated infusion and lavage fluid can effectively reduce intraoperative body temperature loss and avoid hypothermic injury.

Optimization of anesthesia methods general anesthesia and intraspinal anesthesia are generally used in traditional PCNL. General anesthesia is suitable for intraoperative management, controlling respiratory tidal volume and reducing the possibility of pleural injury. Intraspinal anesthesia is also a safe and effective way of anesthesia, but the intraoperative experience is not as good as the former. Wang et al.<sup>[11]</sup> proposed to try to complete PCNL under paravertebral block (PVB) anesthesia. Compared with general anesthesia, PVB reduces the application of opioids, reduces the incidence of perioperative pulmonary complications, and accelerates the postoperative rehabilitation of patients. Studies have shown that subcutaneous injection of anesthetic drugs (ropivacaine or bupivacaine is the first choice) has obvious analgesic effect, which can last for 12 hours, so as to reduce the occurrence of complications such as pulmonary infection and thrombosis<sup>[12]</sup>.

### 3.3. Postoperative

The postoperative diet is traditional. The first postoperative eating can be carried out only after anal exhaust or initial recovery of intestinal function. Postoperative starvation is not conducive to the early recovery of postoperative intestinal function. Eras concept suggests that early postoperative eating should be promoted by maintaining fluid balance, avoiding nausea, vomiting and intestinal paralysis. Early feeding can supplement enteral nutrition, maintain water electrolyte balance, further promote intestinal peristalsis, prevent bacterial migration, reduce the incidence of postoperative infection, shorten hospital stay and promote postoperative recovery<sup>[13]</sup>.

Postoperative nausea and vomiting postoperative nausea and vomiting (PONV) is the main cause of patients' discomfort and prolonged hospitalization. The causes of postoperative nausea and vomiting are multifaceted<sup>[5]</sup>, mainly including patients, anesthesia and surgery. Female patients, non-smokers and patients with a history of motion sickness are particularly at risk. Avoiding the use of inhaled anesthetics and opioids will reduce the risk of PONV. In the currently recognized PONV consensus, serotonin receptor antagonists are recommended as first-line drugs for the prevention of postoperative PONV<sup>[14]</sup>.

Use of drainage tube perioperative drainage aims at early detection and control of complications. In the report of eras consensus, it is recommended not to place drainage tube as far as possible. The indwelling of drainage tube leads to limited activity and pain, which is a potential risk factor for infection in the operation area and prolongs the length of hospital stay<sup>[15]</sup>.

Postoperative analgesia postoperative pain should be actively treated, which may amplify surgical stress response and organ dysfunction and delay postoperative recovery. Postoperative analgesia is the core content of eras concept<sup>[16]</sup>, which is a prerequisite for rapid rehabilitation. Postoperative analgesia under eras concept advocates the use of non steroidal anti-inflammatory drugs and try to avoid the use of opioids.

Early postoperative activities avoid lying in bed after operation. Early out of bed activities can reduce pulmonary complications, insulin resistance, muscle atrophy and shorten hospital stay<sup>[17]</sup>. Early ambulation has been shown to

be an important component in the prevention of postoperative venous thrombosis complications<sup>[18]</sup>. The early activities under eras advocate that they should be implemented within 24 hours after operation, and list the daily exercise goals, which is conducive to the rapid recovery after operation.

Postoperative fluid therapy surgery usually adopts a large amount of fluid replacement to treat intraoperative or postoperative hypotension and maintain fluid perfusion of important organs. Low blood pressure can be avoided by reducing the time of fasting and fasting before operation. Zhen et al.<sup>[19]</sup> believed that excessive fluid treatment after operation would affect patients' cardiopulmonary function, gastrointestinal function and coagulation function. Goal directed fluid therapy (GDFT) in eras concept is currently a more scientific perioperative volume management method, which emphasizes the ability to continuously and instantaneously understand the volume status of the body. The latest research confirmed that target oriented liquid therapy can effectively reduce the incidence of postoperative complications, such as infection, intestinal obstruction, intestinal paralysis, nausea, vomiting and other complications<sup>[20]</sup>. However, how to standardize the perioperative rehydration scheme and the amount of crystal fluid and colloidal fluid is still a subject worthy of study.

#### **4. Application of eras in PCNL of urology**

There are relatively few reports on the application of eras in PCNL in urology. For patients undergoing traditional PCNL, the perioperative nursing of eras has also achieved certain results. Zhuang et al.<sup>[21]</sup> divided 98 patients undergoing PCNL into eras group and control group. General anesthesia was used in both groups. The control group was treated with intravenous patient-controlled analgesia pump after operation, while eras group was treated with incision local infiltration anesthesia + oral nonsteroidal anti-inflammatory drugs before and after operation to relieve pain, early enteral nutrition and early out of bed activities. The results showed that the recovery time of intestinal function and defecation time in eras group were significantly earlier, while the average time in bed after operation was (1.50 ± 0.43) days. The indwelling time of urinary catheter was (1.13 ± 0.23) days and the hospital stay was (4.14 ± 0.85)

days. The postoperative pain score in eras group was lower than that in control group, and the overall satisfaction rate was significantly higher than that in routine group. Li et al.<sup>[22]</sup> randomly divided 120 patients who underwent super mini percutaneous nephrolithotomy (SMP) into experimental group and control group. The experimental group adopted eras nursing mode and the control group adopted traditional nursing. The results showed that the satisfaction of preoperative visit in the experimental group was significantly lower than that in the control group. Due to the control group, the degree of anxiety, the incidence of complications and the length of hospital stay of the patients in the experimental group were significantly lower than those in the control group. Eras nursing mode can promote patients' early postoperative rehabilitation and shorten hospital stay. Zhou et al.<sup>[23]</sup> found that the incidence of postoperative adverse events in the eras mode group was lower than that in the control group and the length of hospital stay was significantly shorter than that in the control group.

#### **5. Application of PCNL based on eras**

The core of eras concept is to reduce the physiological and psychological stress of patients during perioperative period and realize rapid postoperative rehabilitation. Indwelling nephrostomy tube and ureteral stent after traditional PCNL is considered as a standard operation. Indwelling ureteral stent and nephrostomy tube can play the role of support and drainage, and avoid postoperative secondary bleeding and urine extravasation. However, more and more studies have shown that indwelling nephrostomy tube will increase the postoperative pain experience and prolong the hospital stay. In 1984, Wickham et al.<sup>[24]</sup> first proposed the concept of tubeless PCNL. Through the implementation of tubeless PCNL in 100 patients, ureteral stent and nephrostomy tube were not placed during the operation, and there were no obvious complications after the operation, which confirmed the feasibility of tubeless PCNL. However, at that time, there was a great risk of tubeless, and urine extravasation may be caused by tubeless after operation, so tubeless could not be widely used in time. Tubeless PCNL includes partial tubeless PCNL and complete tubeless PCNL. Partial tubeless PCNL does not retain nephrostomy tube, but only ureteral stent tube, while

complete tubeless PCNL does not retain nephrostomy tube or ureteral stent tube. Pande and other researchers believe that tubeless PCNL is mainly suitable for patients with single channel, less bleeding, no collective system perforation and no need for secondary PCNL operation. Tubeless PCNL and standard PCNL are similar in postoperative complications and stone removal rate, but have advantages in postoperative pain score and early activity, shortening hospital stay and reducing cost<sup>[25]</sup>. Through the diagnosis, treatment and experience summary of 231 patients with tubeless PCNL, Zhao et al.<sup>[26]</sup> proposed that the selection of cases with tubeless PCNL should comply with the following aspects:

- ① No injury of renal collecting system during operation and no active bleeding after operation.
- ② There is no need to perform PCNL again.
- ③ There was no obvious infection before and during operation.
- ④ There was no other organ injury during the operation.
- ⑤ The contralateral renal function was good.
- ⑥ If the operation time is  $\leq 2$ H and the operation time is prolonged, it may cause postoperative renal mucosal edema and postoperative bleeding.

Liang Shanling et al.<sup>[27]</sup> referred 43 patients who underwent tubeless PCNL to eras perioperative nursing mode after operation, and found that it can improve the operation effect, reduce postoperative pain, reduce operation and anesthesia related complications, and accelerate the postoperative rehabilitation of patients. Tubeless PCNL is a further optimization of traditional PCNL surgery, which can reduce the postoperative analgesic needs of patients and promote the early postoperative rehabilitation of patients. However, its surgical indications, case selection and prognosis still need to be verified by more clinical studies.

It was found that reducing the size of PCNL channel can reduce channel related complications<sup>[28]</sup>. In 1997, Helal et al.<sup>[29]</sup> and Jackman et al.<sup>[30]</sup> first reported minimally invasive percutaneous nephrolithotomy(MPCNL), which completed MPCNL by establishing 11f-15f channel. At present, channels below 20f are generally called MPCNL. The miniaturization of the channel reduces the damage to the renal parenchyma and collecting system, reduces postoperative pain, reduces the occurrence of complications such as bleeding and urine extravasation, but the operation time is prolonged. Güler et al.<sup>[31]</sup> randomly divided 97

patients into MPCNL group and standard PCNL group. It was found that the decrease of hemoglobin, blood transfusion rate and hospital stay in MPCNL group were lower than those in standard PCNL group. Standard PCNL and MPCNL were safe and effective treatment techniques. Luo Hui et al.<sup>[32]</sup> divided 243 patients with kidney and ureteral stones into traditional group and eras group according to different treatment measures. It was found that there was no significant difference in age, gender, stone size and location, preoperative urinary system infection and operation time between the two groups. Compared with the traditional group, the time of removing nephrostomy tube and urinary catheter was significantly earlier. The patients with hypothermia and postoperative fever in eras group were significantly reduced. In addition, Desai et al.<sup>[33]</sup> reported the concept of micropcnl, which is based on the 4.85 fr PCNL channel for visual operation, and can be crushed without expansion after puncture. Studies have shown that micropcnl can play a unique role in 1.0 cm~1.5 cm kidney stones in adults and children<sup>[34]</sup>. Subsequently, Desai et al.<sup>[35]</sup> reported the application of Ultra Mini percutaneous nephrolithotomy (UMP) with a channel of 3.5 fr. At present, minipcnl, micropcnl and UMP all adopt channel miniaturization to reduce surgical trauma, reduce the occurrence of complications such as renal parenchymal tear and bleeding, collecting system injury and urinary extravasation, promote postoperative rehabilitation and shorten hospital stay, which is consistent with the concept and goal of eras. However, whether the combination with eras has obvious advantages and is beneficial to the prognosis of patients still needs to be confirmed by more clinical studies.

## 6. Conclusion and Prospect

The application of eras concept in perioperative period reduces postoperative pain.

Pain, promote postoperative rehabilitation, shorten hospitalization time and improve patients' hospitalization satisfaction, which is consistent with the goal of PCNL. However, the current limited research can not explain whether PCNL can improve the prognosis of patients on the basis of eras, and the length of hospital stay can not reflect the postoperative recovery of patients. With the improvement of PCNL operation mode and the optimization

of eras concept, we can better achieve the purpose of taking patients as the center, adhering to the principle of individualization and benefiting patients. However, the implementation of eras is still affected by many factors, including the physiological and psychological changes of patients after readmission, compliance with eras concept and postoperative quality of life. It is hoped that with the accumulation of eras clinical practice and the progress of science and technology, eras can be widely used in the treatment of more diseases in the future.

## References

- [1] KEHLET H, MOGENSEN T. Hospital stay of 2 days after open sigmoidectomy with a multimodal rehabilitation programme [J]. *Br J Surg*. 1999, 86(2):227-230.
- [2] LJUNGQVIST O. ERAS--enhanced recovery after surgery: Moving evidence-based perioperative care to practice[J]. *JPEN J Parenter Enteral Nutr*, 2014, 38(5):559-566.
- [3] Li Xun, Wu Kaijun. Multichannel percutaneous nephrolithotomy for the treatment of complex renal calculi [J] *Chinese Journal of Urology*, 1998, 19 (8): 469-470
- [4] Li Xun. Minimally invasive percutaneous nephrolithotomy [J] *Chinese Journal of Urology*, 2008, 29 (10): 656
- [5] GUSTAFSSON UO, SCOTT MJ, HUBNER M, et al. Guidelines for perioperative care in elective colorectal surgery: Enhanced recovery after surgery (ERAS ®) society recommendations:2018[J]. *World J Surg*, 2019, 43(3):659-695.
- [6] PIERRE S, RIVERA C, LE MAÎTRE B, et, al. Guidelines on smoking management during the perioperative period[J]. *Anaesth Crit Care Pain Med*, 2017, 36(3):195-200.
- [7] BURCH J. Preoperative carbohydrate loading in the enhanced recovery pathway[J]. *Br J Nurs*, 2016, 25(12):669-672.
- [8] PIMENTA GP, DE AGUILAR-NASCIMENTO JE. Prolonged preoperative fasting in elective surgical patients: why should we reduce it? [J]. *Nutr Clin Pract*, 2014, 29(1):22-28.
- [9] Li Jieshou. Nutrition and accelerated rehabilitation surgery [J] *Parenteral and enteral nutrition*, 2007, 14 (2): 65-67
- [10] STEELMAN VM, CHAE S, DUFF J, et al. Warming of irrigation fluids for prevention of perioperative hypothermia during arthroscopy: a systematic review and meta-analysis[J]. *Arthroscopy*, 2018, 34(3):930-942. e2.
- [11] Wang Shaogang, Yu Xian. Percutaneous nephrolithotripsy -- a new exploration of daytime surgery [J] *Journal of Peking University (Medical Edition)*, 2017, 49 (5): 753-755
- [12] SALICATH JH, YEOH EC, BENNETT MH. Epidural analgesia versus patient-controlled intravenous analgesia for pain following intra-abdominal surgery in adults[J]. *Cochrane Database Syst Rev*, 2018(8): CD010434.
- [13] TWEED T, VAN EIJDEN Y, TEGELS J, et al. Safety and efficacy of early oral feeding for enhanced recovery following gastrectomy for gastric cancer: a systematic review[J]. *Surg Oncol*, 2019(28): 88-95.
- [14] Branch of surgery, Chinese Medical Association, branch of Anesthesiology, Chinese Medical Association Chinese expert consensus and path management guide for accelerated rehabilitation surgery (2018) [J] *Chinese Journal of Anesthesiology*, 2018, 38 (1): 8-13
- [15] LIU HP, ZHANG YC, ZHANG YL, et al. Drain versus no-drain after gastrectomy for patients with advanced gastric cancer: systematic review and meta-analysis[J]. *Dig Surg*, 2011, 28(3):178-189.
- [16] Li Ning. The key of perioperative management is to accelerate rehabilitation surgery [J] *Chinese Journal of gastrointestinal surgery*, 2015 (7): 635-637
- [17] VAN DER LEEDEN M, HUIJSMANS R, GELEIJN E, et al. Early enforced mobilisation following surgery for gastrointestinal cancer: feasibility and outcomes[J]. *Physiotherapy*, 2016, 102(1):103-110.
- [18] MASTORAKI A, MASTORAKI S, SCHIZAS D, et al. Facing the challenge of venous thromboembolism prevention in patients undergoing major abdominal surgical procedures for gastrointestinal cancer[J]. *World J Gastrointest Oncol*, 2018, 10(10):328-335.
- [19] Guo Zhen, Li Yousheng. Application of perioperative

- fluid therapy in colorectal fast track surgery [J] *Journal of medical postgraduates*, 2011, 24 (9): 993-996
- [20] ZHU AC, AGARWALA A, BAO X. Perioperative fluid management in the enhanced recovery after surgery (ERAS) pathway[J]. *Clin Colon Rectal Surg*, 2019, 32(2):114-120.
- [21] Zhuang Guimin, Yu Luxin, Dong Liying, et al. Application of accelerated rehabilitation surgery in percutaneous nephrolithotomy [J] *Chinese Journal of medical frontier (Electronic Edition)*, 2017, 9 (7): 12-15
- [22] Li Fangxia, Zhang Fangmin, et al. Application of the concept of rapid rehabilitation surgery in the nursing of ultra micro percutaneous nephrolithotomy [J] *International Journal of nursing*, 2017, 36 (10): 1430-1433
- [23] Zhou Hongxia, Liu Jianmin. Effect analysis of clinical nursing application of accelerated rehabilitation surgical nursing concept in patients undergoing percutaneous nephrolithotomy [J] *Chinese general practice*, 2017, 15 (12): 2145-2147
- [24] WICKHAM JE, MILLER RA, KELLETT MJ, et al. Percutaneous nephrolithotomy: One stage or two? [J]. *Br J Urol*, 1984, 56(6): 582-585.
- [25] TIRTAYASA PMW, YURI P, BIROWO P, et al. Safety of tubeless or totally tubeless drainage and nephrostomy tube as a drainage following percutaneous nephrolithotomy: a comprehensive review J]. *Asian J Surg*, 2017, 40(6):419-423.
- [26] ZHAO Y, ZHOU J, SHI Z, et al. A report on safety analysis of tubeless percutaneous nephrolithotomy[J]. *Cell Biochem Biophys*, 2015, 72(2):481-483.
- [27] Liang Shanling, Rao Qingmei, Zhang Yuqin, et al. Application of rapid rehabilitation surgery in patients undergoing tubeless percutaneous nephrolithotomy [J] *Qilu Journal of nursing*, 2016, 22 (10): 80-82
- [28] KUKREJA R, DESAI M, PATEL S, et al. Factors affecting blood loss during percutaneous nephrolithotomy: prospective study[J]. *J Endourol*, 2004, 18(8):715-722.
- [29] HELAL M, BLACK T, LOCKHART J, et al. The Hickman peel- away sheath: alternative for pediatric percutaneous nephrolithotomy J]. *J Endourol*, 1997, 11(3):171-172.
- [30] JACKMAN SV, HEDICAN SP, DOCIMO SG, et al. Miniaturized access for pediatric percutaneous nephrolithotomy[J]. *Journal of Endourology*, 1997, 11(1): S133.
- [31] GÜLER A, ERBIN A, UCPINAR B, et al. Comparison of miniaturized percutaneous nephrolithotomy and standard percutaneous nephrolithotomy for the treatment of large kidney stones: a randomized prospective study J]. *Urolithiasis*, 2019, 47(3):289-295.
- [32] Luo Hui, Chen Xuelian, Li Wenbiao, et al. Application of the concept of rapid rehabilitation surgery in minimally invasive percutaneous nephrolithotomy [J] *Chinese Journal of endoscopic Urology (Electronic Edition)*, 2018, 12 (4): 240-243
- [33] DESAI MR, SHARMA R, MISHRA S, et al. Single-step percutaneous nephrolithotomy (microperc): The initial clinical report[J]. *J Urol*, 2011, 186(1):140-145.
- [34] GHANI KR, ANDONIAN S, BULTITUDE M, et al. Percutaneous nephrolithotomy: Update, trends, and future directions[J]. *Eur Urol*, 2016, 70(2):382-396.
- [35] DESAI J, SOLANKI R. Ultra-mini percutaneous nephrolithotomy (UMP): One more armamentarium[J]. *BJU Int*, 2013, 112(7): 1046-1049.