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6.1 Evolution of Positioning Techniques: Historical Background

In 1929, Dos Santos described the technique of lumbar aortography [1]. This consisted of the oblique insertion of a puncture needle in prone position with an entry point lateral to the vertebral column. The procedure allowed performing renal arteriography helping the diagnosis of kidney tumors. In the following years, lumbar aortography became quite popular and was routinely used. With the patient in the prone position for a translumbar aortogram, Willard Goodwin unintentionally inserted a needle into a hydronephrotic kidney [2]. This gave him the idea of antegrade pyelography and trocar nephrostomy in hydronephrosis [3]. Hence, from the late 1970s, puncturing the kidney during percutaneous nephrolithotomy was based on these previous experiences in the prone position [4].

Classical prone nephrolithotomy consists of two distinct operative steps: placement of a ureteric catheter in the lithotomy position followed by a second positioning in the prone position to create percutaneous access to the kidney and the

nephroscope itself (Figs. 6.1 and 6.2). However, this way of proceeding presents the inconvenience of the necessity of repositioning an intubated and perfused patient. Moreover, in many patients, general anesthesia in the prone position is not tolerated or contraindicated. In morbidly obese patients, the respiration reservoir is restricted because of increased baseline intra-abdominal pressure. This is aggravated in the prone position because of abdominal compression. Narrowing the inferior vena cava results in a decrease in venous return and in cardiac preload.

In 1987, Valdivia Uria reported a new method of patient positioning in the supine position [5]. After ureteric catheterization in the lithotomy position, the patient is repositioned with both legs in extension with an inflatable air bag under the lumbar region, and the ipsilateral arm is placed across the thorax (Figs. 6.3 and 6.4).

Later, this technique was improved by Ibarluzea in the Galdakao hospital [6]. This consists of a modified lithotomy position with the ipsilateral leg extended and the contralateral abducted and flexed. With the exception of this difference, it reproduces the principles of Valdivia (Figs. 6.5 and 6.6). This innovation is known worldwide as the “Galdakao-modified supine Valdivia position” (GMSV). Progressively this modification became increasingly popular. Actually, it allows accessing the urinary tract not only through an anterograde percutaneous route

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Fig. 6.1 Prone position for PCNL: superior view

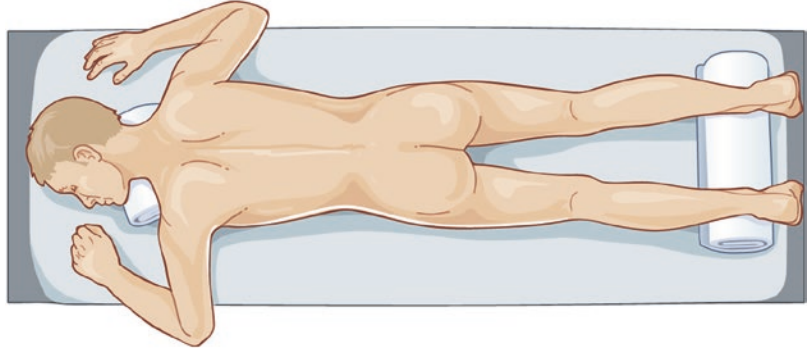


Fig. 6.2 Prone position for PCNL: lateral view



Fig. 6.3 Supine valdivia position: superior view

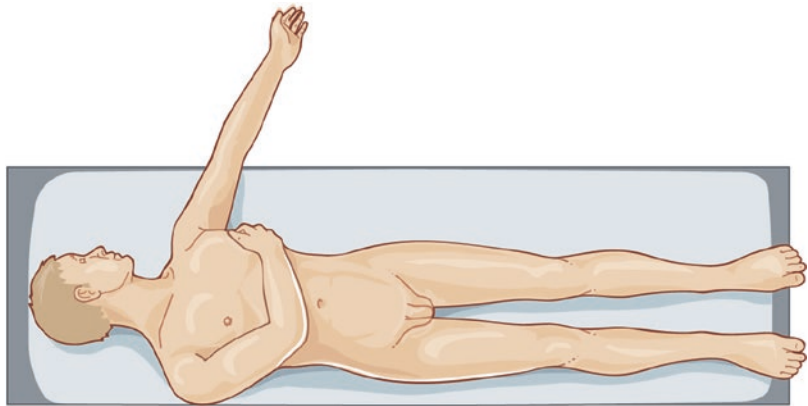


Fig. 6.4 Supine valdivia position: lateral view

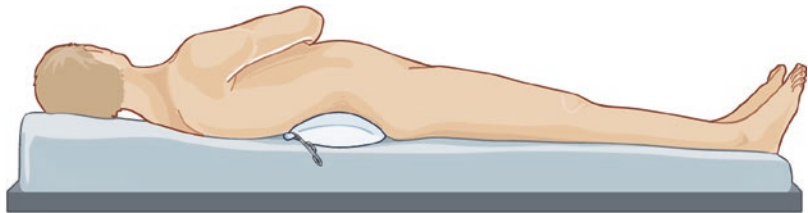


Fig. 6.5 Galdakao-modified supine Valdivia position (GMSV)

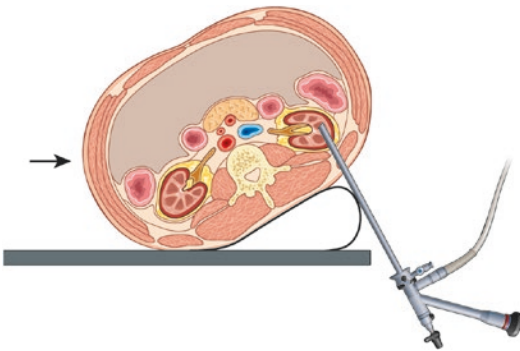
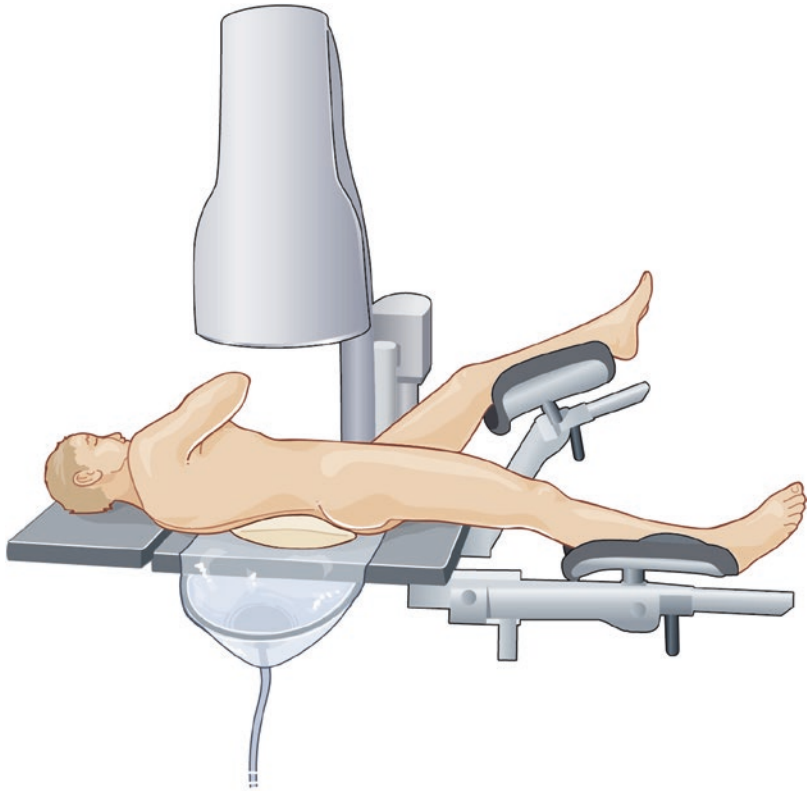


Fig. 6.6 In the GMSV position, the patient is pulled to the border of the table to avoid instrument collisions

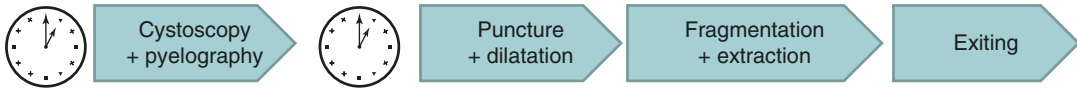
but also via the ureter in the retrograde approach. In addition, two surgeons can work in tandem and perform several tasks simultaneously, opposed to the prone position which usually follows a sequential order.

With the development of flexible instruments, a combination of transurethral and percutaneous routes became possible. This led to the concept of “endoscopic combined intra-renal surgery” (ECIRS), popularized by Scoffone and Cracco [7]. The GMSV position also eliminates the necessity of repositioning the patient who needs to be draped only once. All these characteristics are supposed to shorten operative room occupation time (Fig. 6.7).

However, for many years, the majority of urologists remained faithful to the classical prone position [8]. According to the worldwide prospective study of the Clinical Research Office of the Endourology Society including 5803 patients, 80.3% of still performed the prone PCNL instead of the supine in 2011.

Both for prone and supine positioning, alternatives were proposed to improve ergonomics and outcomes.

PRONE



SUPINE

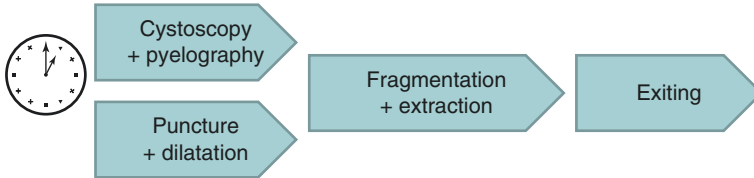


Fig. 6.7 Organigram of PCNL in prone and supine positions

6.2 Variants of Prone and Supine Positions

6.2.1 Prone Variants

Endoscopic combined intra-renal surgery is also possible in the prone position. For this purpose, the reverse lithotomy position [9] and prone split leg position were developed [10] (Fig. 6.8). Using flexible instruments, the bladder and upper urinary tract are accessed even if this can be less ergonomic.

The prone flexed position modifies the anatomical relationships of kidney, thorax and adjacent organs [11] (Fig. 6.9). The kidney is displaced caudally in the retroperitoneum providing improved access to the upper pole, often reducing the necessity of supracoastal puncture. It was reported that 45% fewer supra-11th rib punctures are required to reach the superior calyx. In addition, the distance between the iliac crest and the 12th rib increases, creating more working space. However, this position impairs the patient's respiration, decreases cardiac index and compresses the inferior vena cava.

6.2.2 Lateral Positions

In morbidly obese patients, Kerbl suggested PCNL in lateral decubitus in 1994 [12]. The advantage is that in the lateral position, the pendulous abdomen moves sideways.

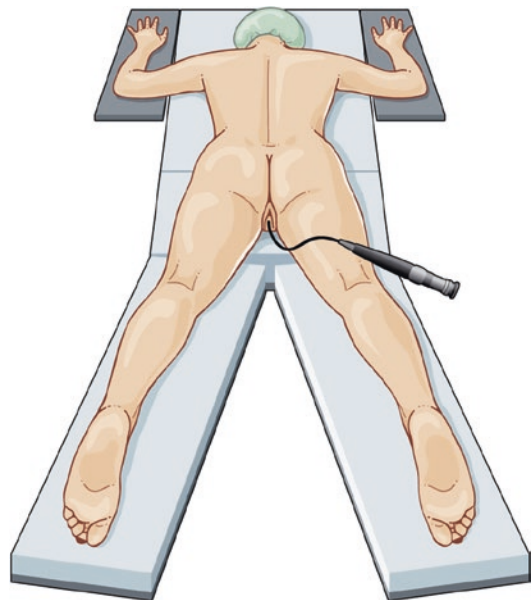


Fig. 6.8 Prone split leg position

However, this position also necessitates a separate time for retrograde ureteric catheterization in the lithotomy position and repositioning in lateral decubitus. In addition, in this position the kidney is projected on the vertebra during fluoroscopy making the puncture and identification of residual fragments difficult.

Bart's technique is a hybrid position that consists of tilting the pelvis 45° with the shoulders perpendicular to the operating table [13]

Fig. 6.9 Prone flexed position

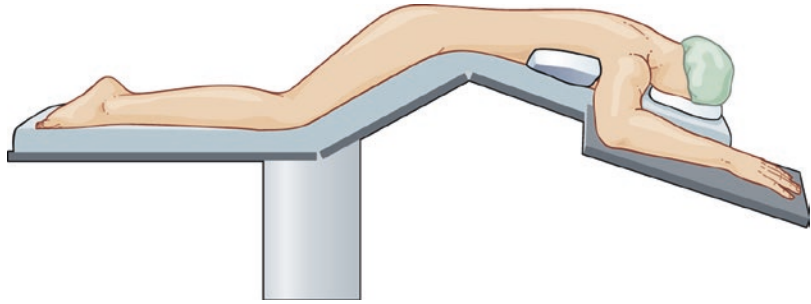


Fig. 6.10 Bart's position

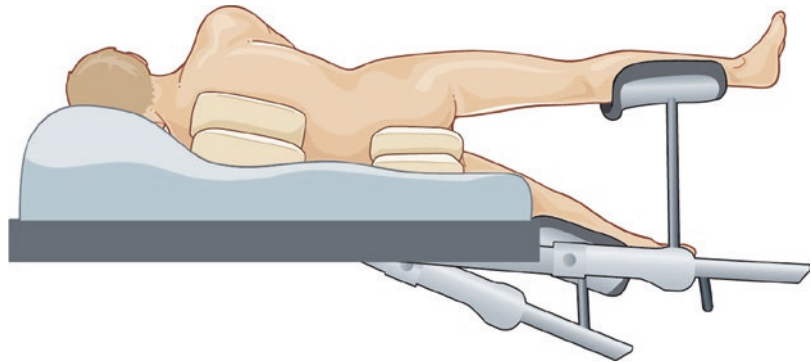
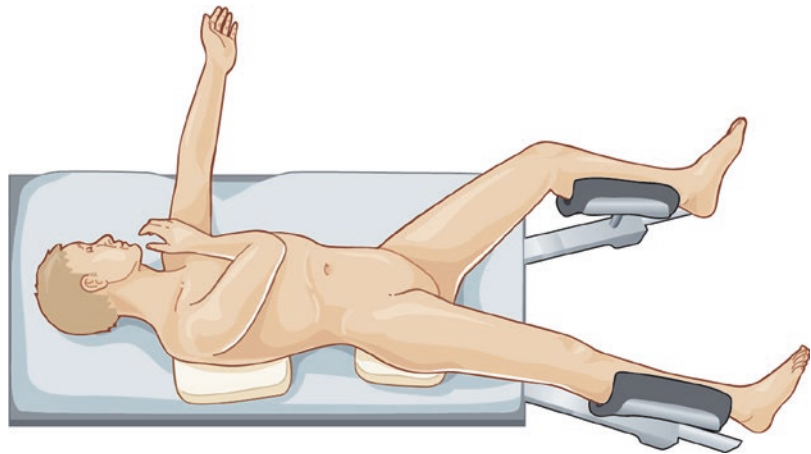


Fig. 6.11 Bart's flank free position



(Fig. 6.10). It requires only one positioning but results in a torque of the vertebral column.

6.2.3 Supine Variants

Besides the already mentioned Valdivia and GMSV positions, these basic techniques also

underwent some minor modifications. One of the most popular is the Bart's flank free position in which the lumbar region is free; the patient is only slightly tilted by using a saline bag under the rib cage and a gel pad under the pelvis [14]. It is suggested that this position exposes the flank better than with other supine positions (Fig. 6.11).

6.3 Advantages and Drawbacks of Each Position

6.3.1 Advantages of Prone Position

Supporters of prone position argue that it offers larger surface area for percutaneous access with more medial access and, in principle, a lower risk of visceral injury. According to anatomical CT studies, despite more anterior puncture during the supine position, the risk of colon perforation is not increased because the bowel floats away from the kidney in the uncompressed abdomen [15].

The prone position is more optimal in simultaneous bilateral PCNL and in some cases of horse-shoe kidney.

Upper pole puncture is believed to be easier in the prone position because it is located more posteriorly and medially. On the other hand, access to the upper pole through a lower calix puncture has been found easier [16]. In a prospective study including 45 patients, Sofer found that access to the upper calix through a lower pole puncture was possible in 20% of prone and 80% of supine percutaneous nephrolithotomies.

6.3.2 Drawbacks of Prone Position

Rolling the patient into the prone position must be undertaken with great care as risks include the potential for cervical spine injury and increased periorbital pressure, which can result in decreased perfusion to the optic nerve and rarely result in vision loss [17, 18]. Performing flexible cystoscopy and ureteroscopy is challenging in the prone position. Handling of the ureteric catheter necessitates specific precautions with respect to surgical asepsis.

6.3.3 Advantages of Supine Position

The supine position offers to the surgical team a great versatility. Simultaneous antegrade and retrograde access to the urinary tract is easy and

comfortable. It also makes possible combining laparoscopy and endourology.

The abdominal wall is punctured more laterally, away from the lumbar muscles; therefore, movements of the endoscope are less restricted. The nephrostomy tube is better tolerated when the patient is lying on his back. The puncture of anterior calices is easier with a better puncture angle.

Horizontal direction of the tract maintains lower pressure which can be a drawback with large Amplatz because the collecting system is collapsed, especially if ultrasound fragmentation with suction is used. However, this reduction in intrarenal pressure counterbalances increased resistance to the outflow of irrigation fluid during different types of miniaturized PCNL. Wash out of fragments is easier because of the pending direction of the Amplatz. During mini-perc, the vacuum cleaner effect is more efficient (Figs. 6.12 and 6.13).

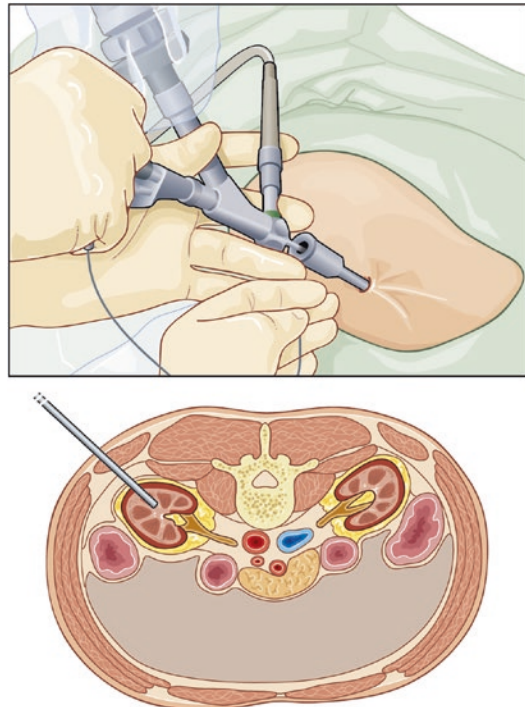


Fig. 6.12 The tract in prone position is oblique leading to slight increase in renal pressure

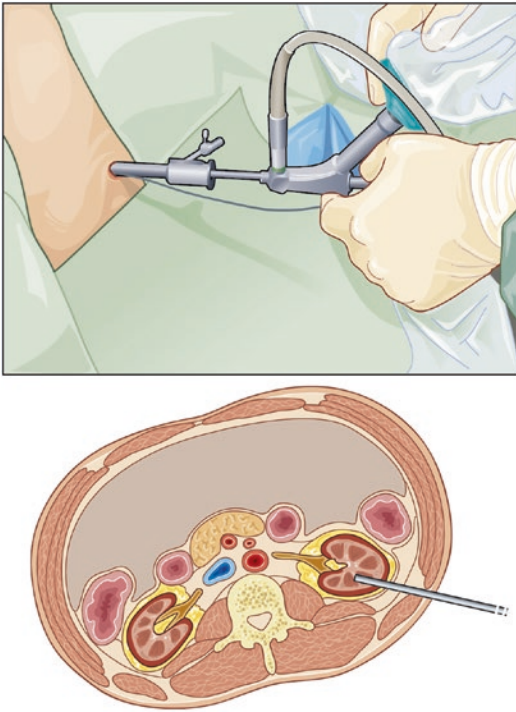


Fig. 6.13 In the supine position, stone clearance is more optimal and vacuum cleaner effect more efficient

6.3.4 Drawbacks of Supine Position

In the beginning, many concerns were formulated relative to the supine position. The main criticism of the supine position is that the flank is not fully exposed, which makes access to the posterior and medially lying upper pole more difficult and provides less availability for multiple accesses.

The operating table and the patient's hips might also restrict instrument manipulation. Therefore, the choice of the nephroscope is fundamental. In older scopes, the light cable and the optical cable are located in the 6 and in the 12 o'clock positions on the instrument. In more recent nephroscopes, the optical and light cables and the irrigation line are connected in the same direction, thus limiting collisions. The patient should also be pulled to the border of the operative table (Fig. 6.14). This somewhat limits the feasibility of the supine position in some opera-

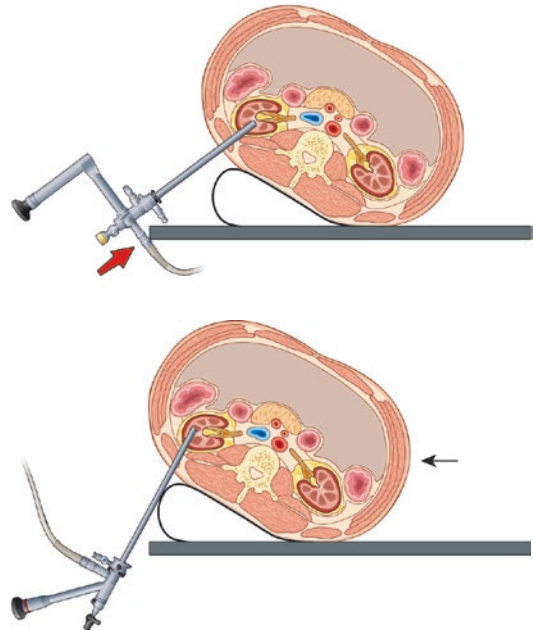


Fig. 6.14 Improper nephroscope design and patient positioning in the middle of the table result in instrument collisions. With modern nephroscopes and the patient pulled to the border of the table, fewer collisions occur

tive rooms equipped with integrated endoscopic-radiologic tables. On these tables, the patient must remain in the middle.

The absence of abdominal compression leaves the kidney more mobile, which can make dilatation of the tract more challenging. This difficulty can be overcome by the through and through the passage of the guidewire.

6.4 Review of the Literature

The clinical research office of the Endourology Society conducted a prospective multicentre study including 5775 PCNL patients from 96 centres worldwide [8, 19]. The conclusions of this ambitious project had a major impact on the opinion of urologic community for many years [20]. At the time of the study, the novel supine position was performed only in 19.7% while the majority of urologists remained faithful to the classical prone position corresponding to 80.3% of cases.

Stone-free rate was superior in the prone group with 77% of patients vs. 70.2% in the supine group ($p < 0.001$). However, the method evaluating residual fragments was dissimilar in the two groups: more patients had postoperative computed tomography in the supine group and the method of evaluation was not mentioned in a larger proportion of patients treated prone.

But the better results in the prone group had also a price in terms of complications. Transfusions were necessary in 6% of patients in the prone group and 4.3% in the supine group. A possible explanation of higher transfusion rate and superior stone-free rate might be a more radical treatment strategy in the prone group. Upper pole puncture was more frequent in the prone group with 11.4% of cases and only 4.0% in supine position. Multiple punctures were used in 9.0% in prone and 4.1% in supine cases. Both upper pole and multiple punctures increase the risk of bleeding.

Complications graded Clavien 2 or more were less frequent in supine group with 7.2% of patients vs. 10% in the prone group. This lower complication rate in the supine position is especially noteworthy as there were more high-risk patients in the supine group. In the prone and supine positions 54.7% vs. 46.8% were ASA1 and 33.4% vs 42.1% were ASA2, respectively.

The conclusions of the CROES study about operative time merit special attention and should be interpreted with caution. Mean operative time was significantly shorter in patients operated in the prone position with 82.7 min and 90.1 min. However, this result is rather misleading. Actually, operative time was defined as puncture to exit [21]. As a result, one of the main advantages of the supine technique, which is single positioning, was simply ignored by the CROES study. Yet, the time necessary to perform ureteric catheterization in the lithotomy position, turning the patient prone, second prepping and draping necessitates at least 20–30 min even in well-organized teams.

The critical analysis of the CROES study is important because later on its data were also

included in several meta-analyses. Because of its sample size, it had a major weight in results.

Two early meta-analyses comparing supine vs. prone position for PCNL have been published. The analysis of Liu was based on 2 prospective RCTs and 2 case-control studies including 389 patients [22]. Besides the results extracted from these 4 studies, Wu included also 27 case series [23]. Both meta-analyses concluded that the supine position shortened the operative time by slightly more than 24 min. The two positions were equivalent to stone-free rate, length of hospital stay and complication rate.

Later, the meta-analysis of Zhang based on 9 studies collected data of 6413 patients. 77.3% of them belonged to the prone group and 22.7% to the supine group. Results showed that PCNL in the supine position was associated with a significantly shorter operative time but stone-free rate was only 72.9% vs. 77.3% in the prone position [24]. However, this study comprised only two randomized trials: one was a prospective non-randomized study and six were retrospective studies with no randomization. Data from the CROES database provided 86.3% of the data.

Presently, the highest evidence level available arises from a recent meta-analysis including exclusively randomized studies [25]. Fifteen studies were selected collecting data from 1474 patients.

Stone-free rate was 78.1% (574/735) in the supine group and 80.0% (591/739) in the prone group; the difference is non-significant. Operative time was slightly but significantly shorter in the supine group with a mean weighted difference of 12.02 min. There was no difference in transfusion rate, urinary fistula, and thoracic complications. However, the risk of fever was significantly higher in the prone group. Hospital stay was similar. But again, the limitation of this meta-analysis is the heterogeneity of reporting among different studies. Other factors than the difference in patient positioning may have an impact on results: puncture and fragmentation techniques, definition of operative time and stone-free rate.

6.5 Conclusion

The main goal of percutaneous nephrolithotomy is to clear the kidney of as much stone as possible in a minimally invasive way. Today, the prone position is no more the exclusive way to do percutaneous nephrolithotomy. There is no clear evidence supporting the superiority of either the prone or supine position regarding stone-free rate, complications and morbidity. Nevertheless, an increasing number of publications admit an advantage of the supine position in terms of operative time.

Yet, the final decision as to the position of the patient belongs to the surgeon according to his personal preference, experience, training and his operative environment. The most important is to do a good job and feel comfortable.

References

1. Dos Santos RLA, Pereira-Caldos J. L'artériographie des membres de l'aorte et de ses branches abdominales. *Soc Natl Chir Bull Meme.* 1929;55:587–601.
2. Goodwin WE. A memoir of percutaneous access to the kidney (antegrade pyelography and percutaneous nephrostomy). *J Endourol.* 1991;5:4.
3. Goodwin WE, Casey WC, Woolf W. Percutaneous trocar (needle) nephrostomy in hydronephrosis. *J Am Med Assoc.* 1955;157:891–4.
4. Castaneda-Zuniga WR, Clayman R, Smith A, Rusnak B, Herrera M, Amplatz K. Nephrostolithotomy: percutaneous techniques for urinary calculus removal. *AJR Am J Roentgenol.* 1982;139:721–6.
5. Valdivia Uribe JG, Lachares Santamaria E, Villarroya Rodriguez S, Taberner Llop J, Abril Baquero G, Aranda Lassa JM. [Percutaneous nephrolithotomy: simplified technic (preliminary report)]. *Arch Esp Urol.* 1987;40:177–80.
6. Ibarluzea G, Scoffone CM, Cracco CM, Poggio M, Porpiglia F, Terrone C, et al. Supine Valdivia and modified lithotomy position for simultaneous antegrade and retrograde endourological access. *BJU Int.* 2007;100:233–6.
7. Scoffone CM, Cracco CM, Cossu M, Grande S, Poggio M, Scarpa RM. Endoscopic combined intrarenal surgery in Galdakao-modified supine Valdivia position: a new standard for percutaneous nephrolithotomy? *Eur Urol.* 2008;54:1393–403.
8. Valdivia JG, Scarpa RM, Duvdevani M, Gross AJ, Nadler RB, Nutahara K, et al. Supine versus prone position during percutaneous nephrolithotomy: a report from the clinical research office of the endourological society percutaneous nephrolithotomy global study. *J Endourol.* 2011;25:1619–25.
9. Lehman T, Bagley DH. Reverse lithotomy: modified prone position for simultaneous nephroscopic and ureteroscopic procedures in women. *Urology.* 1988;32:529–31.
10. Grasso M, Nord R, Bagley DH. Prone split leg and flank roll positioning: simultaneous antegrade and retrograde access to the upper urinary tract. *J Endourol.* 1993;7:307–10.
11. Ray AA, Chung DG, Honey RJ. Percutaneous nephrolithotomy in the prone and prone-flexed positions: anatomic considerations. *J Endourol.* 2009;23:1607–14.
12. Kerbl K, Clayman RV, Chandhoke PS, Urban DA, De Leo BC, Carbone JM. Percutaneous stone removal with the patient in a flank position. *J Urol.* 1994;151:686–8.
13. Moraitis K, Philippou P, El-Husseiny T, Wazait H, Masood J, Buchholz N. Simultaneous antegrade/retrograde upper urinary tract access: Bart's modified lateral position for complex upper tract endourologic pathologic features. *Urology.* 2012;79:287–92.
14. Bach C, Goyal A, Kumar P, Kachrilas S, Papatouris AG, Buchholz N, et al. The Barts 'flank-free' modified supine position for percutaneous nephrolithotomy. *Urol Int.* 2012;89:365–8.
15. Tuttle DN, Yeh BM, Meng MV, Breiman RS, Stoller ML, Coakley FV. Risk of injury to adjacent organs with lower-pole fluoroscopically guided percutaneous nephrostomy: evaluation with prone, supine, and multiplanar reformatted CT. *J Vasc Interv Radiol.* 2005;16:1489–92.
16. Sofer M, Giusti G, Proietti S, Mintz I, Kabha M, Matzkin H, et al. Upper calyx approachability through a lower calyx access for prone versus supine percutaneous nephrolithotomy. *J Urol.* 2016;195:377–82.
17. Addla SK, Rajpal S, Sutcliffe N, Adeyoju A. A simple aid to improve patient positioning during percutaneous nephrolithotomy. *Ann R Coll Surg Engl.* 2008;90:433–4.
18. Miano R, Scoffone C, De Nunzio C, Germani S, Cracco C, Usai P, et al. Position: prone or supine is the issue of percutaneous nephrolithotomy. *J Endourol.* 2010;24:931–8.
19. de la Rosette J, Assimos D, Desai M, Gutierrez J, Lingeman J, Scarpa R, et al. The Clinical Research Office of the Endourological Society percutaneous nephrolithotomy global study: indications, complications, and outcomes in 5803 patients. *J Endourol.* 2011;25:11–7.
20. Kamphuis GM, Baard J, Westendarp M, de la Rosette JJ. Lessons learned from the CROES percutaneous nephrolithotomy global study. *World J Urol.* 2015;33:223–33.
21. Yamaguchi A, Skolarikos A, Buchholz NP, Chomon GB, Grasso M, Saba P, et al. Operating times and bleeding complications in percutaneous nephrolithotomy: a comparison of tract dilation methods in 5,537 patients in the Clinical Research Office of the Endourological

- Society Percutaneous Nephrolithotomy Global Study. *J Endourol.* 2011;25:933–9.
22. Liu L, Zheng S, Xu Y, Wei Q. Systematic review and meta-analysis of percutaneous nephrolithotomy for patients in the supine versus prone position. *J Endourol.* 2010;24:1941–6.
 23. Wu P, Wang L, Wang K. Supine versus prone position in percutaneous nephrolithotomy for kidney calculi: a meta-analysis. *Int Urol Nephrol.* 2011;43(1):67–77.
 24. Zhang X, Xia L, Xu T, Wang X, Zhong S, Shen Z. Is the supine position superior to the prone position for percutaneous nephrolithotomy (PCNL)? *Urolithiasis.* 2014;42:87–93.
 25. Li J, Gao L, Li Q, Zhang Y, Jiang Q. Supine versus prone position for percutaneous nephrolithotripsy: a meta-analysis of randomized controlled trials. *Int J Surg.* 2019;66:62–71.