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Our clinical experience with the videoassisted lumbar sympathectomy. Application of laser Dopppler flowmetry to monitor the course and effects of the procedure

The procedure of lumbar sympathetic denervation has been the subject of much controversy over its indications as well as early and late therapeutic results. The indications for lumbar sympathectomy has been undergoing a real evolution since 1923, when Royle performed such an operation in a patient with spastic paralysis of the lower limb (13). In 1926 Adson used this method in Raynaud's phenomenon (1). In Buerger's disease lumbar sympathectomy was performed by Diez. Until the 50' when vascular grafts and restoration of patency in reconstructive operations of arteries became common procedures, lumbar sympathectomy was a recognized operative method in the treatment of lower limbs ischaemia. At present, due to dynamic development of techniques of arterial reconstruction using venous or prosthetic by-passes and endovascular procedures, the indications for sympathetic denervation in ischaemic diseases are limited to peripheral atherosclerosis, inflammatory arterial diseases and advanced forms of vasospastic disorders. The method used presently is an open procedure with the anterior-transverse and anterior-lateral access. The progress in videoscopic techniques and their use in sympathetic denervation at thoracic level widened possible indications for sympathectomy, particularly in hyperhidrosis where decreased incidence of injuries, minimal number of complications and satisfactory cosmetic results could be observed. These facts resulted in further attempts to use videoscopic methods in lumbar sympathectomy. The videoscopic methods of lumbar sympathectomy were first described by Biedermann (2) in 1994 and Hourlay (7) in 1995. Our first videoassisted lumbar sympathectomy was performed in 1996 (15). The aim was to develop a method requiring simple instruments, giving satisfactory therapeutic and cosmetic results and reducing the length of surgery.

In 18 cases, to monitor the course of videoscopic lumbar sympathectomy and for objective evaluation of its short and long term effects, we applied the method of laser Doppler flowmetry to register a functional influence of the procedure on peripheral skin microcirculation. Generally, the sympathectomy – abolishing vasoconstrictor tone – leads to vasodilatation of skin blood vessels and thus increases skin blood flow (3, 10).

MATERIAL AND METHODS

Seventy-two videoassisted lumbar sympathectomies performed in 46 patients (19 women and 27 men) in the Department of Vascular Surgery and Angiology of the Medical University of Lublin were included in the analysis. Last 18 procedures were additionally monitored by laser Doppler flowmetry method. The indications for surgery were as follows: *thromboangiitis obliterans* in 24 cases (33.33%), atherosclerotic lesions in peripheral arteries in 16 (22.22%), fect

hyperhidrosis in 20 (27.77%) and primary Raynaud's phenomenon in 12 cases (16.66%). The average age of the patients was 41.8 years.

The videoassisted retroperitoneal lumbar sympathectomy (VALS). Under general anesthetic with endotrachial intubation patient is positioned with the operated lumbar region elevated by 30 degrees. Depending on the thickness of the subcutaneous tissue, skin is incised 3–4 cm transversely, at the border of hypochondrium and epigastrium. Below the subcutaneous tissue, the sheath of the *rectus abdominis* is exposed and incised transversely for up to 15 mm. The *rectus abdominis* is retracted medially and the posterior wall of the muscle exposed medially. The sheath is then incised transversely. The incision is then extended up to 5 cm to the *transversalis fascia*, over which the muscle has been earlier delaminated. Bleeding from incised vessels is carefully controlled. The peritoneum that is visible is separated delicately with a finger by pushing it downwards and the retroperitoneal space is reached medially. The space between the iliopsoas muscle and the vertebral column marks the place where the sympathetic trunk is located. Subsequently, because the retractor, which creates and maintains the appropriate operative space, is required, two Tiemann hooks are used. The endoscope is inserted into this space. Usually, 0 degree optics. While applying the 30 degree optics it is useful to apply a trocar laterally along the skin incision line. After the exposure of the sympathetic trunk, and following identification of the appropriate ganglia, the ganglia L2 and L3 are coagulated by means of a L-hook and subsequently divided with scissors. Drainage of the retroperitoneal space is not necessary. Interrupted sutures to the fascia, the sheath of the *rectus abdominis*, the subcutaneous tissue and skin (a cosmetic subcuticular suture can be used) complete this procedure (15).

Laser Doppler Flowmetry (LDF). To monitor the course of the videoassisted lumbar sympathectomy and objectively evaluate its effectiveness, during last 18 procedures we measured the peripheral skin perfusion and temperature by means of laser Doppler flowmetry. Laser Doppler Flowmeter DRT 4 ®- Moor Instruments Ltd / England was used. DRT 4 enables continuous and simultaneous registration of the skin perfusion and temperature. The method of Laser Doppler Flowmetry is already applied in many fields of medicine. Laser light is directed towards the skin via a glass optical fibre. A fraction of the light is reflected off the skin surface, but the majority enters the tissue, where it undergoes a complex process of scattering and absorption. The light scattered back from moving red blood cells undergoes a frequency shift according to Doppler effect. The backscattered light, both Doppler shifted and unshifted is collected by a fibre optic system and directed onto a photodetector. There, it is transformed to a photocurent, which is analysed in the processor. The output of the processor is a voltage related to blood flux (11, 12).

Laser Doppler probe was positioned on the plantar surface of the foot of the sympathectomized extremity and secured by double sided, adhesive discs. This position enabled easy access to the probe during measurements and simultaneously protected against artefacts which might have been induced by movements of the operation team. The localisation of the probe was precisely determined and maintained during every measurement. Specially constructed edge of the probe maintained a constant distance between the probe and skin surface and direction of laser beam. Light fibres were attached to the skin to avoid artefacts caused by accidental movements. All measurements were conducted about the same time of a day, in thermostatically controlled surgery room, with constant temperature (23+/–1°C), after 20 min acclimatisation period in supine position.

We evaluated the changes of blood flow in skin microcirculation and skin temperature before, during, 2 h and 24 h after the surgery. The periods of 5-min recordings with a stable skin blood flow and skin temperature were considered in the analysis. The period of surgical procedure was continuously monitored to observe the changes in skin perfusion during stimulation and coagulation of the lumbar sympathetic trunk ganglia.

The obtained data were analysed with PC software DRTSOFT® / Moor Instruments Ltd, England. The primary results were expressed as the mean values, in arbitrary units. Due to interindividual variability of resting parameters data were subsequently transformed to the percentage format. Changes in the skin temperature were given in °C. To evaluate the statistical

significance of the observed differences, we applied the paired t-Student test. The results were considered to be statistically significant when $p < 0.05$.

RESULTS

The videoassisted retroperitoneal lumbar sympathectomy (VALS). The follow-up period ranged from two to 48 months. Forty-six patients subjected to 72 operations were followed up. Thirty-nine patients (84.72%) who underwent 63 procedures (87.5% of surgeries performed) are still under ambulatory control.

Perioperative results. The follow-up period for perioperative results was 30 days after operations. The average surgery length was 25 min. In 70 procedures (97.22%) performed in 45 patients (97.82%) the videoassisted method was applied.

Sixty-seven operations (93.05%) performed in 41 patients (89.13%) brought about satisfactory clinical effects. The healing process of trophic ulceration was observed as well as rapid demarcation of necrotic areas, regressed rest pains and increased claudication distance. In vasospastic disorders no complaints connected with abnormal vascular reaction to temperature were reported. In patients with hyperhidrosis, foot sweat secretion was significantly reduced. Peristalsis occurred 10–22 hours after surgery. No respiratory and cardiovascular complications were noted. The patients resumed ambulation within 24 hours. They complained only of some discomfort in the wound regions. Patients underlined good cosmetic effects resulting from small incisions.

In two cases (2.77%) the videoassisted procedures were converted to open surgery (in both of them the lumbar vein was detached from the inferior caval vein during hook fixation). In one patient with hyperhidrosis, the iliolumbar nerve was injured intraoperatively, which caused the disorders of the thigh motor activities. Despite rehabilitation, the functions were not fully restored. In two patients (2.77%) suffering from *thromboangiitis obliterans* with limb ischaemia, after initial improvement, the ischaemic symptoms aggravated.

Early results. The follow-up period ranged from 30 days to six months and involved 41 patients (89.13%) subjected to 68 sympathectomies (94.44% of procedures). Positive postoperative effects were observed in 34 patients (82.93%) who underwent 58 operations (85.29%). In patients operated because of lower limb ischaemia, further healing of ulcerations and necrosis resulting from spontaneous or surgical removal of ischaemic debris was observed. The patients reported reduced rest pains and increased walking distance. In patients with vasospastic symptoms, the pathological signs were significantly reduced or disappeared. In patients operated on for hyperhidrosis, a significant decrease in foot sweat secretion was observed.

In one patient, with four-limb hyperhidrosis subjected to bilateral sympathectomy after previous bilateral thoracic sympathectomy, the compensatory hyperhidrosis of the trunk developed two months later. In another patient suffering from *thromboangiitis obliterans*, the postsympathectomy syndrome developed in the right lower limb, 35 days after the operation. Within two months the symptoms of severe burning pain in the anterior and medial thigh and groin and the disorders of thigh and calf motor functions, gradually subsided. In one patient with *thromboangiitis obliterans* subjected to bilateral sympathectomy, critical ischaemia of the right foot developed three months after the operation. In three patients with primary Raynaud's phenomenon, who underwent five sympathetic denervation procedures (7.35%), the symptoms relapsed two to three months after surgery. However, these patients found them insignificant and slightly affecting their normal functions.

Late results. The late results were evaluated between 6^{th} and 48^{th} postoperative month. The follow-up included 39 patients (84.78%), who underwent 63 sympathectomies (87.5% of the operations). No recurrences were observed. The vasodilating and antiplatelet drugs were administrated in the group of patients with peripheral limb ischaemia while oral β-blockers and vasodilatants to those with vasospastic symptoms. In the group with hyperhidrosis (beside the case with compensatory trunk hyperhidrosis described above) no recurrences or symptoms of

compensatory sweat secretion in other parts of the body were observed. The patients reported: postoperative good general condition, early ambulation, quick return to normal alimentary functions, no respiratory disorders, short hospitalization periods, good cosmetic effects.

Laser Doppler Flowmetry (LDF). Introduction of epidural analgesia led to slight increase of skin blood flow in all 18 cases. During the procedure, stimulation of sympathetic trunk produced transient and reversible drop of skin perfusion. Following coagulation and segmental resection of sympathetic trunk resulted in continuous elevation of blood flow values. These were 30.2% on average higher at the end of procedure, when compared to preoperative recordings ($p<0.05$). The temperature of the foot did not change significantly.

Two hours after the surgery the skin blood flow was still increasing. Perfusion on the sympathectomized foot was 21.3% on average higher than this recorded at the end of the procedure. Local temperature rose by 1.0°C on average, when compared to preoperative measurements. Both differences were statistically significant ($p<0.05$). 24 h after the sympathectomy, further significant increase ($p<0.005$) in skin perfusion and skin temperature was observed (25.7% and 1.1°C respectively).

DISCUSSION

The videoassisted retroperitoneal lumbar sympathectomy (VALS). The introduction of vascular grafts and the development of the endovascular techniques resulted in significantly decreased use of lumbar sympathectomy in ischaemic diseases of the lower limbs. Moreover, the progress achieved in conservative management of primary Raynaud's phenomenon limited the operative procedures of sympathetic denervation to the cases with advanced ischaemic changes. Doubtful results of sympathectomy in foot frostbites eliminated it from the therapies used in frost-caused diseases. Due to extensive incisions in common open sympathectomy methods, they were rarely used in foot hyperhidrosis. For many years the surgeons have stressed the disproportion between the size of the operative space and the extent of injuries to the abdominal integuments. However, when the method of videoassisted thoracic sympathectomy was introduced, the reduction of the lumbar sympathectomy injuries became possible. The early reports of Biedermann (2) and Hourlay (7) regarded closed videoscopic methods, in which creating and retaining the space by CO_2 insufflation was difficult and often ineffective. The similar closed methods were described by Chesire (4) and Kathouda (9). All of them were connected with a time-consuming creation of the operative space. The use of fingers in 12 mm-long incisions is difficult and the risk of peritoneal injuries very high. The 25 mm-incision described by Elliott (5) is only slightly smaller than the incision in our method and is one of the three incisions used in closed procedures. Moreover, sealing up such an incision after inserting the valvar trocar is troublesome. The skin incision in our method ranges from 30 to 40 mm depending on the patient's weight and is the only incision performed during the operation.

Due to difficulties in maintaining a good visibility in the operating space, Wattanasirichaigoon (14) suggested the use of transperitoneal videoscopic methods. In our method the CO_2 insufflation was replaced by inserting Tiemann's hooks, which resulted in accurate maintenance of the operative space. The use of the method of videoassisted endoscopy improved inspection of surgical area and significantly shortened the length of the procedure.

Since the groups of patients in the reports discussed earlier were small, the postoperative results cannot be compared. In our material it is noteworthy that in 97.22% of the cases in which the videoassisted method was used, only in two procedures (out of 72) the conversion to open surgery was required. In 93% of the cases the clinical outcome was good, which was confirmed by the doctors and patients. In two patients with ischaemic symptoms due to atherosclerotic lesions and Buerger's disease the late results revealed ischaemic recurrences. However, these findings are not univocal since late effects could result from the natural development of the disease, continous exposure to risk factors or possible regeneration of sympathetic trunks, which was discussed recently. Moreover, the compensatory trunk hyperhidrosis was observed in the patient with four

limb hyperhidrosis who underwent bilateral thoracic and lumbar sympathectomy. In other studies such a phenomenon after thoratic sympathectomies was reported in 22–67% of the cases (6, 8).

Small number of intraoperative complications results from good evaluation and identification of the structures operated by our method. Compared to closed methods, quick and easy access to the sympathetic trunk, no problems with insufficient insufflation shorten the length of the procedure.

Our patients stress a short period of abdominal discomfort, quick restoration of peristalsis and no respiratory disorders. They resumed ambulation quickly and thus their hospital stay was short. The patients are particularly satisfied with good cosmetic results.

Laser Doppler Flowmetry (LDF). In many studies the influence of pharmacological or surgical sympathectomy on skin microcirculation was investigated. Generally, the sympathectomy – abolishing vasoconstrictor tone – leads to vasodilatation of skin blood vessels and thus increases skin blood flow (3,10).

Therefore, we stated that laser Doppler flowmetry with laser/temperature probes positioned on the plantar surface of the foot might be a precise method for functional identification of sympathetic trunk ganglia and monitoring of the videoassisted lumbar sympathectomy. Additionally it was presumed that therapeutical effects of this procedure could be assessed in an objective way.

During videoassisted lumbar sympathectomy small skin incision and indirect – via video camera – observation of the surgical area, sometime may result in problems of sympathetic trunk identification, especially in case of less experienced surgeons. Sympathetic ganglia can be mistaken with other anatomical structures like lymphatic vessels and nodes. There are even some reports in the literature regarding accidental injuries of the ilio-lumbar nerve or ureter (15).

In our study, recording of skin microvascular responses during stimulation and coagulation of some structures in the area of sympathetic trunk allowed us the functional identification of its ganglia. In all 18 cases dissection in the area of sympathetic trunk and its mechanical stimulation led to decrease of skin blood flow on the operated side. The decrease of blood flux was short in time and transient, pointing on neural type of reaction. The skin temperature did not follow short time variations of skin blood flow, probably due to high thermal capacity of the skin. On the other hand, after the coagulation and segmental resection of the sympathetic trunk, the permanent, increasing trend in skin perfusion associated with gradual elevation of the skin temperature was observed on the sympathectomized extremity. High skin perfusion and temperature values, comparing to the pre-surgery period, were present two 24 h after the sympathectomy, pointing to high effectiveness of this type treatment. The permanent improvement in skin perfusion accompanied by increase of its temperature seems to be an adaptive response regulated by neural and thermoregulatory mechanisms.

CONCLUSIONS

1. The videoassisted lumbar sympathectomy is a safe and easy procedure.
2. The method may be recommended for treatment of peripheral ischaemia of the lower limbs, hyperhidrosis of the feet and in cases of primary Raynaud's phenomenon.
3. Intraoperative application of laser Doppler flowmeter enables precise and functional identification of the sympathetic trunk structures during videoassisted lumbar sympathectomy and allows an objective assessment of the procedure results.

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SUMMARY

The aim of the study was to define the advantages and pitfalls of the videoassisted retroperitoneal lumbar sympathectomy (VALS) in the treatment of peripheral arterial occlusive diseases, hyperhidrosis and primary Raynaud's phenomenon. Additionally, laser Doppler flowmetry was applied during 18 procedures to monitor the course and effects of the procedure. Seventy-two sympathectomies by VALS performed in 46 patients (27 males and 19 females, average age 41.8 years) were included in the analysis. Indications were: *thromboangiitis obliterans* (n=24), peripheral arteriosclerotic occlusive disease (n=16), hyperhidrosis (n=20) and Raynaud's phenomenon (n=12). In every case, original, videoassisted retroperitoneal lumbar sympathectomy without insufflation of the retroperitoneum was performed. Peripheral skin blood flow before, during and after the sympathectomy was continuously registered by means of laser Doppler flowmetry during 18 procedures. No early or late deaths occurred. The mean time of the procedure was 25 min. In 93% of the cases the results were good. Two intraoperative conversions to open procedures were necessary due to the lumbar vein injury. In one of the first cases a lesion of ilio-lumbar nerve was observed. In the late results, one case of compensative abdomen hyperhidrosis, five cases of mild Raynaud's phenomenon recurrence and one case of critical limb ischemia recurrence in a patient with Buerger's disease were observed. The method of laser Doppler flowmetry was helpful to confirm functionally the accurate, intraoperative, anatomical identification of lumbar sympathetic trunk and served for objective assessment of the procedure effectiveness. In all of the 18 monitored cases, the stimulation of sympathetic trunk during surgery evoked short-term and reversible decrease of peripheral skin blood flow. Resection of the segment of sympathetic trunk resulted in progressive increase of skin perfusion and its temperature. VALS is a safe and easy procedure recommended in the treatment of peripheral lower limb ischemia, foot hyperhidrosis and primary Raynaud's phenomenon. Intraoperative application of laser Doppler

flowmetry is suitable for functional identification of the lumbar sympathetic trunk as well as for objective evaluation of the results after surgery.

Sympatektomia lędźwiową wykonywana własną metodą wideoasysty – nasze doświadczenia kliniczne. Zastosowanie metody laserowej przepływometrii dopplerowskiej do monitorowania i oceny skuteczności zabiegu

Celem pracy była ocena wyników sympatektomii lędźwiowej wykonywanej z dojścia zaotrzewnowego metodą wideoasysty (VALS). Dodatkowo podczas 18 zabiegów oceniano obwodowy przepływ skórny metodą laserowej przepływometrii dopplerowskiej w celu monitorowania przebiegu zabiegu i obiektywnej oceny jego skuteczności. Analizie poddano siedemdziesiąt dwie sympatektomie lędźwiowe wykonane u 46 pacjentów (27 mężczyzn i 19 kobiet, średni wiek 41,8 lat). Wskazaniami do zabiegu były: zakrzepowo-zarostowe zapalenie tętnic (n=24), miażdżyca obwodowa (n=16), nadpotliwość (n=20), pierwotny fenomen Raynauda (n=12). W każdym przypadku zabieg przeprowadzono własną, zaotrzewnową metodą wideoasysty. W 18 przypadkach zmiany przepływu skórnego krwi przed, w trakcie i po zabiegu rejestrowano w sposób ciągły metodą laserowej przepływometrii dopplerowskiej. W okresie obserwacji nie było zgonów. Średni czas zabiegu wynosił 25 minut. W 93% wyniki były dobre. Tylko w dwóch przypadkach wystąpiła konieczność konwersji do metody otwartej z powodu śródoperacyjnego naderwania żyły lędźwiowej i krwawienia. Podczas jednego z pierwszych zabiegów doszło do uszkodzenia nerwu biodrowo-lędźwiowego. W odległym okresie obserwacji u jednego z chorych wystąpiła kompensacyjna nadpotliwość okolicy brzucha. w pięciu przypadkach doszło do nawrotu fenomenu Raynauda o łagodnym przebiegu oraz w jednym przypadku do krytycznego niedokrwienia kończyny dolnej u pacjenta z chorobą Buergera. Metoda laserowej przepływometrii dopplerowskiej umożliwiała czynnościową identyfikację struktur pnia współczulnego i ocenę skuteczności zabiegu. U wszystkich 18 pacjentów śródoperacyjne drażnienie pnia współczulnego wywoływało krótkotrwały i odwracalny spadek perfuzji skórnej na obwodzie kończyny. Natomiast przerwanie ciągłości pnia współczulnego prowadziło do stopniowego wzrostu przepływu skórnego i temperatury skóry. Zaotrzewnowa sympatektomia lędźwiowa wykonywana metodą wideoasysty jest bezpiecznym i łatwym zabiegiem zalecanym w leczeniu obwodowego niedokrwienia kończyn dolnych, nadpotliwości stóp i pierwotnego fenomenu Raynauda. Śródoperacyjne zastosowanie laserowej przepływometrii dopplerowskiej jest przydatne do czynnościowej identyfikacji pnia współczulnego jak i obiektywnej oceny skuteczności zabiegu.