# Ambulatory Conservative Hemodynamic Management of Varicose Veins: Critical Analysis of Results at 3 Years

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This report describes the results of our 3-year experience using ambulatory conservative hemodynamic management (ACHM) for lower extremity venous insufficiency involving the greater saphenous vein (GSV), with specific analysis of recurrence due to neoformation of vessels. We performed 289 ACHM procedures in 259 consecutive patients with GSV-related varicose veins. Follow-up clinical examination and Doppler ultrasound imaging was carried out at 3, 6, 12, 24, and 36 months in all cases to assess formation of neovessels supplied either by the superficial (A) or deep (B) venous system. Our data showed that ACHM achieved excellent improvement, with complete disappearance of varicose veins in 41.2% of cases, good improvement in 43%, fair improvement in 14.1%, and no improvement in 1.7%. The only predictor of outcome was the quality of drainage from the GSV vein. Poor drainage leads to neoformation of vessels supplied by the superficial (A) venous system. In about 50% of cases, drainage appeared spontaneously within 1 year, with a subsequent reduction in formation of neovessels. Neoformation of vessels supplied by the deep (B) venous system (10%) was independent of the quality drainage. This finding suggests that formation of these neovesseis is unrelated to the surgical method used to treat varicose veins. In patients with poor drainage of the saphenous network, neoformation of vessels supplied by the superficial (A) venous system is predictable with regard to both topography and delay. ACHM is a good tool for treatment of varicose veins, as reliable statistical prediction of mid-term results is possible using available models. (Ann Vasc Surg 2000;14:376-384.)
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## INTRODUCTION

For many years, saphenous vein stripping was considered to be the method of choice for treatment of varicose veins of the lower extremities.[1-4] In 1988, Franceschi[5] described a new method called *ambulatory conservative hemodynamic management* (ACHM), which consists of minimally invasive surgical procedures under local anesthesia that are based on the findings of careful hemodynamic analysis of the venous network of the lower limb using pulsed Doppler ultrasound. We have performed over 600 ACHM procedures. In the present study, we describe the outcome of 289 of these procedures in 259 consecutive patients. Outcome is based on assessment of neoformation of vessels by clinical examination and Doppler ultrasonography.

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## PATIENTS AND METHODS

### Principles of ACHM

The goal of ACHM for superficial venous insufficiency (SVI) is to relieve the hydrostatic pressure

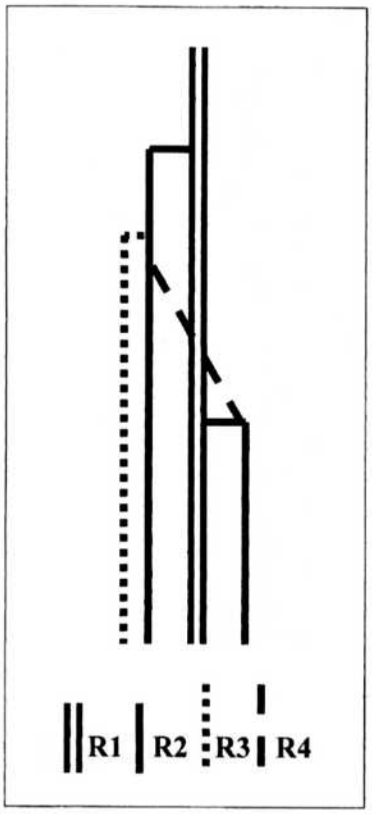


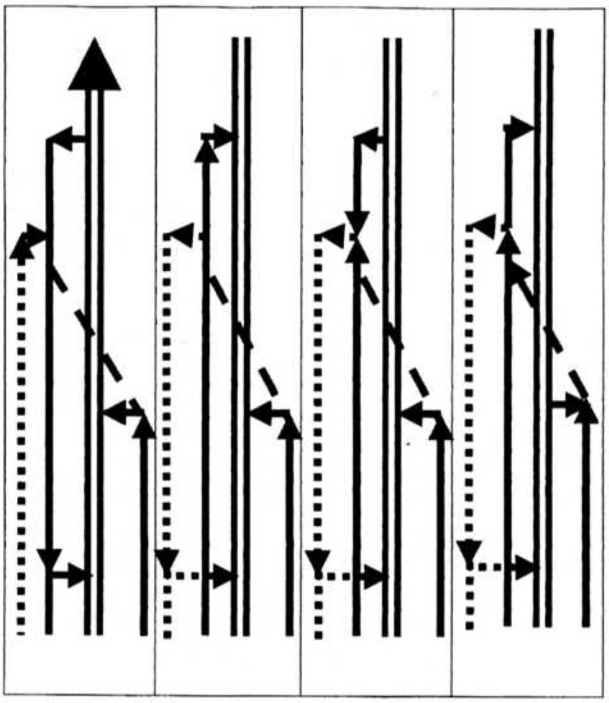

**Fig. 1.** Drawing representing the four venous networks of the lower extremities. *R1*, deep venous network, including veins located beneath the fascia. *R2*, superficial venous network, including veins located between superficial fascia layers (saphenous veins, Giacomini vein). *R3*, saphenous vein collaterals located above the superficial fascia with no connection to any vessel in the R2 network. *R4*, saphenous vein collaterals located above the superficial fascia with connection to a vessel in the R2 network, either at the origin (longitudinal R4L) or otherwise (transverse R4T).

column by deleting venovenous shunts without removal of the saphenous vein or disruption of drainage of superficial tissue. Hemodynamic studies of patients with SVI have demosntrated four main shunt patterns, depending on communication between four venous networks: R1 (deep vein), R2 (subfascial saphenous veins and Giacomini vein), R3 (branches of the suprafascial saphenous veins), and R4 (saphenous branches between saphenous veins) (Fig. 1). As a result of muscle contraction, many incompetent saphenous veins empty in anterograde fashion via the saphenofemoral junction. When muscles relax, these saphenous veins refill by reflux via the saphenofemoral junction and empty in a retrograde fashion into one or more distal perforators, which act as reentry points. These reentry points can be located on the saphenous vein (P/PR2) or its collaterals (P/PR3). Both anterograde and retrograde flow drain into the deep venous network. Thus flow can be stopped by suppressing the drainage route. Since the saphenofemoral junction usually constitutes the point of reentry of anterograde flow, crossectomy leads to disappearance of anterograde flow but does not affect retrograde flow. Conversely, since the distal perforating veins constitute the point of reentry for retrograde flow, their disruption leads to disappearance of retrograde flow without affecting anterograde flow. In both cases, flow continues in the saphenous vein during either muscle relaxation or contraction, thus ensuring drainage into the deep venous system. By preventing reentry of either anterograde or retrograde flow, we obtain a draining saphenous system, i.e., a system able to empty in either the retrograde or anterograde direction, respectively. Conversely, if both anterograde and retrograde flow are prevented, we obtain a non-draining saphenous system in which no emptying occurs at velocities detectable by Doppler ultrasound.

Thus saphenous vein hemodynamics can be manipulated by performing one or more surgical procedures to adjust reentry of anterograde flow, which is usually also the point of reflux and/or reentry of retrograde flow, depending on the type of venovenous shunt[6] (Fig. 2). A variety of procedures are possible and together constitute the basis for ACHM of varicose veins (Figs. 3 and 4). The characteristic feature of ACHM is to be not only conservative but also hemodynamic.

Assuming that any treatment for varicose veins must eliminate venovenous shunting, preservation of the saphenous vein becomes a necessary but insufficient criterion for ACHM. Two other criteria are required to qualify as an ACHM procedure. The first is that the preserved saphenous system must empty in one direction at a sufficient velocity to allow drainage of cutaneous and subcutaneous circulation into the deep vein network. The emptying direction depends on the therapeutic procedure used and emptying velocity depends on the choice of reentry points. The second requirement for qualification as an ACHM procedure is reduction in filling pressure. This depends on both prevention of reflux and proper adjustment of emptying velocity.

It would be illogical to define ACHM as a procedure resulting in a nondraining saphenous system in which anterograde flow has been stopped but no retrograde flow is detectable. Absence of retrograde saphenous flow is not related to reestab-



I II III IV

**Fig. 2.** Different venovenous shunts that may be observed during Doppler ultrasound examination as defined by Franceschi.[5] *Type I,* reflux from the saphenous vein with reentry through a perforating vein located on the saphenous vein (P/R2). *Type II,* reflux from a saphenous vein collateral (R3) with a competent saphenous vein. *Type III,* reflux from the saphenous vein with reentering perforating vein from the collateral vein (P/R3). There can be several types, depending mainly on the length of the refluxing saphenous segment. The shared feature is the disappearance of saphenous reflux during diastole when the origin of the collateral giving rise to the reentry vein is compressed. *Type IV,* any type of shunt other than those described above.

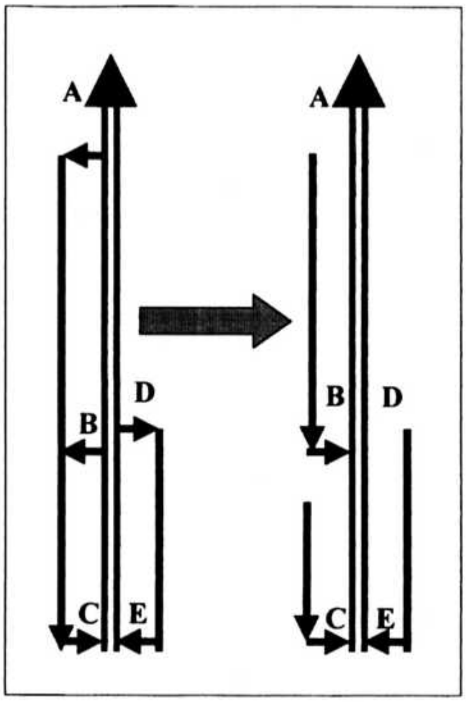



**Fig. 3.** Example illustrating the principles of ACHM for type I venovenous shunts. The internal and external saphenous veins show reflux through junctions *A* and *D,* respectively, and through perforating vein *B* with reentry points through distal perforating veins (terminals) *C* and *E.* Crossectomy of junction *A* eliminates saphenofemoral reflux and relieves the hydrostatic pressure column. Termination may (as here) or may not be associated with division/ligation of the saphenous vein below the refluxing perforating vein which thus becomes the new reentry vein. This type of termination should be used only if the perforating vein can accommodate sufficient flow for efficient drainage. Crossectomy of junction *D* (preferentially below the origin of the Giacomini vein) has the same effect.

lishment of valve competence due to reduction in the diameter of the saphenous vein lumen, as reported by several authors,[7] but rather to inadequate reentry flow due to poor preoperative evaluation; retrograde flow was always observed in draining saphenous systems despite the same reduction in GSV diameter as in nondraining systems.

In our experience, we were not always able to obtain draining saphenous systems for two reasons. The first was poor hemodynamic significance of the perforating veins used for reentry. The second involves special anatomophysiological features of the varicose venous system, which will be discussed below. The purpose of this study was to determine if the course of varicose disease was influenced more favorably by a draining saphenous system than a nondraining saphenous system.

## Patients

All patients with incompetence of the greater saphenous vein (GSV) were considered candidates for ACHM. From January 1990 to July 1994, we performed 289 ACHM procedures on 259 consecutive patients, including 60 men and 199 women, presenting varices in the region of the GSV. Mean age was 49.1 ± 12.4 years (range, 20 to 79 years). Pulsed Doppler ultrasound was performed in all cases for careful preoperative evaluation of the whole venous network of the lower extremities.

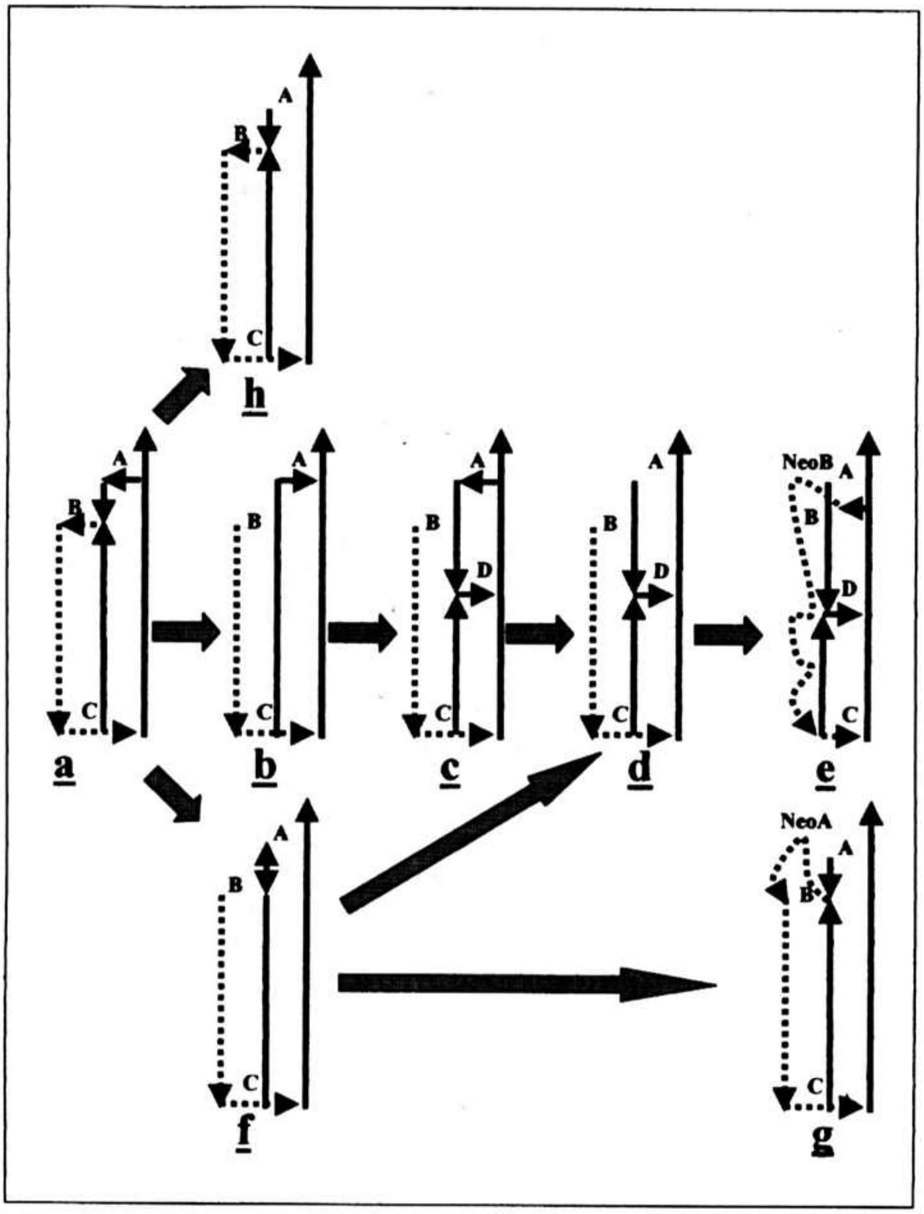



**Fig. 4.** Examples illustrating the principles of ACHM for type III venovenous shunts and analysis of recurrences due to formation of type A or type B neovessels, depending on whether a draining saphenous system was achieved. **a** Type III shunt, **b** Stage I of ACHM-2 preventing reflux at point B and preserving drainage through junction A. **c** Progression to a type III shunt after development of the reentering perforating vein D. **d** Stage II of ACHM-2 with crossectomy of junction B. **e** Development of neovessels supplied by the deep network (type B) is not correlated with the procedure itself. Development of type B neovessels is probably related to either the presence of a undetected perforating vein or unexplained development of a secondary opening. **f** ACHM-1+2 with division/ligation at point B and crossectomy of junction A. This procedure cannot be considered a true ACHM procedure since it results in a nondraining saphenous system with stasis between A and B. However, this nondraining ACHM can be transformed into a draining ACHM (d) secondarily by development of a perforating vein under the effect of residual pressure. **g** If this transformation does not occur, residual pressure in the nondraining segment will lead to development of a type A neovessel bridging the division ligation at point B, causing recurrence without reflux from the deep venous system. **h** Isolated crossectomy of junction A achieves a draining system without deep reflux. This system meets the hemodynamic requirements of management but leaves a superficial type II shunt that may cause a small but uncosmetic R3 network.

Unilateral or bilateral incompetance of the GSV was documented in all cases. Preoperative diameter of the GSV, which was measured in 254 cases at a distance of 15 cm below the junction with femoral veins, varied from 4 to 13 mm (mean, 6.8 ± 1.8 mm). Thirty patients presented with primary deep valve insufficiency (DVI) and four presented with post-thrombotic secondary DVI. Thirty-eight patients were obese. In 26 lower extremities, ACHM was associated with phlebectomy of saphenous branches.

### Methods

In all cases veins in the lower extremity were carefully marked during preoperative Doppler ultrasound examination to identify the shunt pattern[5] (Fig. 2) and to determine vessels to ligate or remove. Surgery was performed under local anestheisa and lasted approximately 1 hr in all cases. Patients were allowed to walk immediately and to leave the institution about 30 min after the procedure. All patients were asked to return for clinical examination and Doppler ultrasound at 3, 6, and 12 months and then every year after the procedure. A minimum follow-up period of 36 months was required for inclusion in this study.

For analysis of outcome, patients were divided into two groups, depending on whether the resulting saphenous system was draining or nondraining. The draining ACHM group (D.ACHM) included cases in which good anterograde or retrograde flow was observed throughout follow-up. The nondraining ACHM group (ND.ACHM) included cases in which anterograde or retrograde flow was undetectable at any one time during follow-up. Within the second group, we also analyzed the difference in outcome in cases in which a P/R2 perforating vein eventually developed so that the nondraining saphenous system was spontaneously transformed into a draining saphenous system.

Neoformation of vessels appeared to be a good criterion for evaluating the outcome of ACHM, as we took into account not only clinically visible new vessels but also new vessels detectable by Doppler ultrasound. Careful mapping by Doppler ultrasound at each scheduled follow-up allowed monitoring of neoformation. Neovessels were classified into the following two categories:

1. Type A neovessels: varices without reflux from the deep venous system characterized by a negative response to the Valsalva maneuver, i.e., neovessels bridging the R2-R2 or R3-R3 ligature or the R2-R3 or R2-R4 compartment (Fig. 2).
2. Type B neovessels: varices with reflux from the deep venous system characterized by a positive response to the Valsalva maneuver, i.e., neovessels bridging the R1-R2 or R1-R3 compartments.

Improvement at 3 years was graded as excellent if varices disappeared completely, good if residual or new varices were minimal, fair if residual or new varices persisted but the situation was better than before, and poor if there was no improvement or the varicose network reappeared during follow-up. Any patient who underwent further surgical treatment or sclerotherapy at any time during follow-up was classified in the poor or fair result group.

Statistical analysis was performed using the Student's $t$-test for independent parametric values and the Pearson and McNemar test for nonparametric values. When necessary, the Bonferroni difference theory was applied as described by Glantz.[8]

## RESULTS

### Overall Results

No death or major complication was observed in this series. Partial thrombosis of the GSV occurred in 72 cases (24.9%). It spontaneously recanalized in 68 cases, at a mean follow-up of 5 months. Secondary surgical treatment or sclerotherapy of collateral saphenous veins was performed for cosmetic reasons in 27 cases. Almost all these cases involved collateral veins in the thigh with low reentry points, and hence partially visible after the procedure. All secondary procedures were performed using the same technique after marking by means of Doppler ultrasound.

Excellent improvement was obtained in 119 cases (41.2%); no visible varice was observed at any time during follow-up. Good improvement was obtained in 124 cases (43%), with residual varices and neoformation of vessels being minimal. Fair improvement was obtained in 41 cases (14.1%); the situation was better compared to the preoperative status but residual varices and/or neovessels were observed. Poor improvement was obtained in five cases (1.7%) in which the situation did not change or worsened.

Recurrences involved type A neovessels that were clinically visible in 42 cases (14.5%) and detectable by Doppler ultrasound in 72 cases (24.9%), and type B neovessles that were clinically visible in 21 cases (7.2%) and detectable by Doppler ultrasound in 30 cases (10.3%).

**Table I.** Comparison of patients in the D.ACHM AND ND.ACHM groups

| | D.ACHM | ND.ACHM | $p$ |
|---|---|---|---|
| Procedures ($n$) | 198 | 91 | |
| Gender | 145 F | 65 F | NS |
| Mean age (years) | 48.4 ± 11.7 | 50.8 ± 13.6 | NS |
| Size of varices | | | |
| 0 | 2 | 0 | |
| 1 | 66 | 17 | <0.001 |
| 2 | 108 | 48 | |
| 3 | 22 | 26 | |
| Saphenous vein diameter | | | |
| Patients ($n$) | 177 | 77 | NS |
| Mean diameter | 6.7 ± 1.7 | 7.1 ± 2 | |
| Obese patients | 25 | 13 | NS |
| PDVI | 19 | 11 | NS |
| SDVI | 2 | 2 | NS |
| Phlebectomy | 19 | 2 | NS |

NS, not significant; PDVI, primary deep vein insufficiency; SDVI, secondary deep vein insufficiency.

**Table II.** Comparison of outcome after D.ACHM and ND.ACHM groups

| | D.ACHM (198 procedures) | ND.ACHM (91 procedures) | $p$ |
|---|---|---|---|
| *GSV thrombosis* | 20 | 52 | <0.001 |
| *Improvement* | | | <0.001 |
| Excellent | 93 | 26 | |
| Good | 89 | 35 | |
| Fair | 13 | 28 | |
| Poor | 3 | 2 | |
| *Recurrences* | | | |
| Type A neovessels | | | |
| Clinically visible | 10 | 32 | <0.001 |
| Detectable by ultrasound | 18 | 54 | <0.001 |
| Type B neovessels | | | |
| Clinically visible | 13 | 8 | NS |
| Detectable by ultrasound | 21 | 9 | NS |

NS, not significant.

## Results in the D.ACHM and ND.ACHM Subgroups

The D.ACHM group identified by Doppler ultrasound included 198 procedures and the ND.ACHM group included 91 procedures. These two groups were comparable with regard to age, gender, incidence of valve incompetence in the deep venous network, and incidence of obesity (Table I). Comparison of the mean preoperative diameter of the greater saphenous vein showed no significant difference between the D.ACHM and ND.ACHM groups. Nor was there any significant difference between the two groups with regard to the number of secondary phlebectomies carried out on collateral sapheous veins (R3) for cosmetic reasons.

The incidence of thrombosis was 10.1% (20 cases) in the D.ACHM group versus 59% (52 cases) in the ND.ACHM group ($p < 0.001$). As shown in Table II, there was a highly significant correlation between saphenous vein drainage and neoformation of clinically visible or ultrasound-detectable vessels. Qualitative analysis showed no statistical difference between the D.ACHM and ND.ACHM groups with regard to formation of clinically visible or ultrasound-detectable type B neovessels. Con-

**Table III.** Comparison of size of varices and diameter of GSV in patients with or without recurrence in D.ACHM and ND.ACHM groups

| | D.ACHM | | | ND.ACHM | | |
|---|---|---|---|---|---|---|
| | No recurrence | Recurrence | | No recurrence | Recurrence | |
| Procedures | 175 | 23 | | 33 | 58 | |
| Size of varices | | | | | | |
| 0 | 2 | 0 | | 0 | 0 | |
| 1 | 60 | 6 | | 10 | 7 | |
| 2 | 95 | 13 | NS | 14 | 34 | NS |
| 3 | 18 | 4 | | 9 | 17 | |
| GSV diameter | | | | | | |
| *n* | 158 | 19 | | 31 | 46 | |
| Diameter | 6.6 ± 1.7 | 6.9 ± 19 | NS | 6.8 ± 1.6 | 7.6 ± 2.1 | NS |

NS, not significant.

versely, there was a significant difference ($p < 0.001$) between the two groups with regard to formation of clinically visible or ultrasound-detectable type A neovessels. Within the D.ACHM and ND.ACHM groups, comparison of patients in whom recurrence was or was not observed showed no significant difference with regard to the size of varices or diameter of the GSV (Table III). In 49 cases in the ND.ACHM group, development of a perforating reentry vein along the distal GSV (P/PR2) led to saphenous vein drainage spontaneously within a period of 6 to 24 months after the procedure. In 15 of these cases, formation of type A vessels was observed before develoment of the reentry perforating vein. In contrast, formation of type A vessels was observed after development of the reentry perforating vein in only two cases. This difference was statistically significant ($p < 0.005$; McNemar test).

## DISCUSSION

The findings of this study show that the determinant factor for outcome of ACHM is the quality of drainage of the saphenous vein system. The incidence of recurrence due to formation of type B neovessels was the same in the D.ACHM and ND.ACHM groups. Conversely, the incidence of recurrence due to formation of type A neovessels was significantly higher in the ND.ACHM group. This finding demonstrates that outcome depends on the quality of drainage of the saphenous vein system. This study also showed that secondary development of a reentering perforating vein can transform a nondraining system into a draining system, thereby greatly reducing the likelihood of formation of type A neovessels.

To obtain a draining saphenous system, ACHM strategy must take into account the hemodynamic pattern of the venous network. The original procedure proposed by Francheschi[5] for all types of venovenous shunts was, in fact, only one possible ACHM technique (ACHM-1) (Fig. 3). After identification of the perforating vein most likely to provide the best reentry point, the saphenous vein was divided and tied at the saphenofemoral junction to prevent reflux at the most proximal level. Collateral veins from the junction to the saphenous vein were left patent so as to insure optimal retrograde flow (at low pressure and low flow). At the same time, the vessel giving rise to the reentering perforating vein was interrupted about 2 cm below the mouth of the perforating vein. In this way, the reentering perforating veins was "terminalized" and the hydrostatic pressure column of the superficial venous system was relieved (Fig. 3). In cases involving nonterminal, refluxing perforating veins,[9] terminalization included elimination of secondary venovenous shunts generated by the perforating veins. This technique (ACHM-1) achieved good results for patients with type I shunts (Fig. 3), which account for about 33% of the total population with varicose veins. Conversely, results were poor in patients with type 3 shunts, which account for about 60% of the total population (Fig. 4a). The drawback of ACHM-1 in patients with type III venovenous shunts was the preesence of secondary shunts generated by R2-R3 reflux from the collateral that was not disconnected from the saphenous vein (Fig. 4h). This cause of failure was obvious in patients in whom this collateral was superficial (R3) and thus visible after the procedure.

This problem led Franceschi and Bailly[6] to develop a two-stage technique (ACHM-2) for type III shunts. The first stage was designed to modulate venous hemodynamics by disconnecting the origin of the collaterals giving rise to the reentering perforating vein that allowed retrograde reflux (P/R3). The goal of this step was to transform a refluxing saphenous system into a saphenous system with anterograde reflux in which the point of reentry was the junction (Fig. 4b). Following the first step, reflux should no longer be detected in the junction by Doppler ultrasound after compression and release (Fig. 4b). The second stage was carried out after formation of a functional reentry vein, thanks to the development of a P/R2 perforating vein. At this time, the system can be considered a refluxing system similar to that of a type I shunt (Fig. 4c) that can be treated by crossectomy (Fig. 4d).

However, ACHM-2 is not safe in patients presenting with type 3 short saphenous vein insufficiency, i.e., confined to the upper half of the thigh. In these cases, in fact, ACHM-2 carries the risk of extension of thrombosis from the upper saphenous vein into the common femoral vein. To prevent this complication, Franceschi and Bailly[6] proposed use of a hybrid technique (ACHM-1+2) involving simultaneous ligation of the origin of the collateral vein giving rise to the reentry perforating vein and the saphenofemoral junction (Fig. 4f). This procedure results in a saphenous vein system with practically no drainage presenting a high risk of thrombosis of the saphenous vein. Subsequently, the vessel can be recanalized by either formation of P/R2 perforating vein (Fig. 4d) or neoformation of vessels (Fig. 4g) at the level of the ligation of the collateral vein giving rise to the reentry perforating vein (ligature "bridging"). Recanalization by formation of a P/R2 perforating vein leads to a spontaneously draining saphenous system with a low propensity for formation of neovessels. Conversely, recanaliation by ligature bridging creates the need to empty the system and thus leads to formation of type A neovessles that may connect with the previous network or a new P/R3 perforating vein. In any case, since it results in a nondraining system, ACHM-1+2 is a conservative but nonhemodynamic technique and hence does not qualify as a true ACHM procedure.

The main difference between ACHM and other conservative treatment techniques is thus clear. In over 50% of cases, crossectomy in association with interruption or phlebectomy of collaterals leads to a nondraining saphenous system with a higher incidence of neoformation of vessels. Conversely, like valvuloplasty of the saphenofemoral junction, successful crossectomy or isolated ligation of the saphenous vein at the saphenofemoral junction leads to a draining saphenous system but only treats the point of reflux in patients with primary shunts (R1-R2). Secondary shunts (R2-R3 and R2-R4) resulting from incompetent collaterals or refluxing perforating veins remain patent.[2]

Stripping of the saphenous vein is a good surgical procedure in terms of simplicity, rapidity, and safety. It does not require long hemodynamic evaluation or complicated mapping and the operative technique is well defined. By definition, however, stripping prevents drainge from the territory of the GSV. We thus sought to determine if the benefits of ACHM outweighed the long period of time required for hemodynamic mapping and the high investment needed for equipment.

Previous authors reporting on the results of stripping only took into account clinically visible neovessels. Examinations for detection of infraclinical neovessels were not performed. In our series, postoperative follow-up included both clinical examination and Doppler ultrasound, so we were able to monitor total neoformation, including both clinically visible and infraclinical neovessels.

In the past three decades, only a few authors[4,10-14] have described 3-year results of stripping of the saphenous vein. Comparison of these results with our overall results, i.e., including those from both the D.ACHM and ND.ACHM groups, indicate that ACHM compares favorably with stripping. It is likely that this comparison would probably have been even more conclusive for ACHM if only D.ACHM had been taken into account.[15]

These findings demonstrate that hemodynamic study, which is the basis for ACHM, is an effective method for evaluation of varicose veins. The validity of current models is confirmed by the fact that statistical methods can predict certain potential events, e.g., formation of type A neovessels. The major findings of this study can be summarized as follows:

1. The preoperative diameter of the GSV is not correlated with formation of neovessels and thus with outcome.
2. Secondary procedures carried out on R3 for cosmetic reasons do not affect the outcome of ACHM.
3. The quality of drainage from the treated GSV is the only factor correlated with outcome of ACHM.
4. Formation of type A neovessels in nondraining saphenous systems can be predicted in terms of topography and delay.
5. Formation of type A neovessels transforming a ND.ACHM into a D.ACHM and leading to a re-

duction in neoformation can be predicted by statistical methods.

6. Formation of type B neovessels is not correlated with the quality of drainage of the treated GSV. The incidence of type B neovessels is about 10% regardless of whether the saphenous vein system is draining or nondraining. Although this type of neoformation probably has a strong influence on the outcome of any type of surgical treatment, it has not been described in the literature. The most likely reason for this oversight is that postoperative Doppler ultrasound has not been widely used to detect infraclinical neovessels.
7. Results of ACHM at 3 years are at least as good as those reported with the same follow-up for stripping of the saphenous vein.

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