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Benign Neural Sheath Tumours of Major Nerves: Characteristics in 119 Surgical Cases

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Summary

Peripheral benign nerve sheath tumours are infrequent tumours and affect major nerve trunks. Some authors have indicated a high and prohibitive incidence of neurological injury in resection of these lesions. The authors describe their findings in a retrospective study comprising 119 patients with spontaneous benign nerve sheath tumours of the peripheral nervous system. Seventy-three patients had a schwannoma, 41 had neurofibroma and 5 had plexiform neurofibroma; 25 of the 119 patients suffered from neurofibromatosis. All schwannomas were excised completely and the outcome of patients was 41.0% improved, 6.8% worsened, 52.0% unchanged. Twenty-eight neurofibromas were excised completely and 13 subtotally; the outcome for patients was 19.5% improved, 19.5% worsened and 61% unchanged. All plexiform neurofibromas were removed subtotally and the outcome for patients was 20% improved and 80% unchanged. The best surgical results at average follow-up of 6 years were observed in the patients with schwannoma, the worst in those with plexiform neurofibroma. Our results demonstrated that it is often possible to remove schwannomas as well as neurofibromas with an acceptable risk of injury to the nerve.

Keywords: Schwannoma; neurofibroma; neurofibromatosis; peripheral nerve tumour.

Introduction

Peripheral benign nerve sheath tumours are infrequent tumours and affect major nerve trunks [2, 12–14]. The tumour may grow in an exophytic fashion from a root or may involve the entire nerve root with the nerve fibers intermingled inside the substance of the mass. In clinical practice, difficulties may arise when the probable behaviour of the tumour has to be predicted on the basis of its gross appearance and consequently its treatment [4, 5, 16, 23, 32, 38, 45]. Some authors [24, 39, 45] have indicated a high and prohibitive incidence of neurological injury in resection of these lesions.

Our study of peripheral spontaneous benign nerve sheath tumours was undertaken with the purpose of identifying the therapeutic modality most likely to offer optimal chances of cure and to evaluate the relationships between gross appearance and results of treatment.

Patients and Methods

Between 1980 and 1995 we observed 119 cases of benign spontaneous nerve sheath tumours. In 73 (61.3%) cases the lesion was a schwannoma, in 41 (34.4%) a neurofibroma and in 5 (4.2%) a plexiform neurofibroma. Twenty-five patients (21.0%) had type 1 neurofibromatosis (NF); 2 patients who did not have NF had multiple schwannomas affecting different nerves (Table 1).

Schwannoma was lobulated, firm and circumscribed by a connective tissue capsule. Characteristic Schwann cells were disposed either in compact bundles (Antoni A pattern) or in loose textured arrangements (Antoni B pattern). Atypias and mitoses were absent.

Neurofibroma was cirumscribed, less well encapsulated in relationship to the nerve of origin (35 cases; 85.3%) or fascicle (6 cases; 14,7%). The tumours were characterized by spindle-shaped cells in a myxomatous matrix with a more prominent mucopolysaccharide staining and reticulum. There was not a compact array of cell characteristics of schwannomas.

Plexiform neurofibroma is a type of neurofibroma that usually involves deep nerve trunks and results in fusiform swelling and nodular enlargements extending peripherally and proximally along the nerve. The distinguishing factor between schwannomas and neurofibromas was the tendency of neurofibromas to have more fascicles entering and exiting the tumour at its poles, or to have one relatively large contributing and exiting fascicle.

Strength and sensation were graded from 0 to 5 using the grading scale reported by Donner [16] (Tables 2–5).

Ultrasonography was performed in 30 patients, electromyography and CT were performed pre- and postoperatively in all

Table 1. *Sex, Age, and Site*

	Schwannoma	Neurofibroma	Plexiform neurofibroma
Sex	38M-35F	25M-16F	3M-2F
Mean age (yrs)	46	28	26
Site:			
supraclavicular brachial plexus	3	2	
infraclavicular brachial plexus	4	2	
median nerve	21	11	3
ulnar nerve	12	8	
radial nerve	24	12	2
LS plexus	2	3	
femoral complex	1	1	
sciatic complex	6	2	

Table 2. *Pre- and Post-operative Motor Grade in 73 Patients with Schwannomas*

	Pre-operative motor grade					Total
	5	4	3	2	1	
Postoperative motor grade						
5	12	10				22
4	1	11	9	2		23
3		1	12	2	2	17
2				3	5	8
1				3		3
Total	13	22	21	10	7	

Table 3. *Pre- and Post-operative Motor Grade in 41 Patients with Neurofibromas*

	Pre-operative motor grade					Total
	5	4	3	2	1	
Postoperative motor grade						
5	6	3				9
4		5	3			8
3		2	9	1		12
2			4	4	1	9
1			2		1	3
Total	6	10	18	5	2	

patients, whereas MRI was performed pre- and post-operatively in 32 patients (Table 7 a–c.).

A microsurgical technique was used in all cases; the fascicles were dissected free of the tumour in the extracapsular plane and as the tumour was exposed, care was taken to isolate fascicles. When it was helpful to debulk large tumours, a longitudinal incision was made in the capsule between fascicles. When necessary, nerve grafting was performed for repair of nerve injuries. Intra-operative nerve action potential studies were performed both prior to and following excision of the lesion.

Follow-up evaluation was undertaken from 1 to 16 years post-operatively (mean 6 years).

The data about site, size, diagnosis and treatment of tumours have been summarized in Tables 1, 5, 7 a–c, 8.

Table 4. *Pre- and Post-operative Motor Grade in 5 Patients with Plexiform Neurofibroma*

	Pre-operative motor grade					Total
	5	4	3	2	1	
Postoperative						
5						
4						
3						
2			1		1	2
1			1	2		3
Total			2	2	1	

Table 5. *Status of Pain after Operation on Tumours*

Type	Resolved	Improved	Unchanged	Worsened	New pain
Schwannoma	43	16	7	4	3
	58.9%	21.9%	9.6%	5.4%	4.1%
Neurofibroma	14	9	10	4	4
	34.1%	21.9%	24.4%	9.7%	9.7%
Plexiform					
Neurofibroma		1	2	1	1
		20%	40%	20%	20%

Table 6. *Type of Operative Procedure in Our Cases*

Type	Schwannoma	Neurofibroma	Plexiform neurofibroma
Total excision	73	28	
Subtotal excision		13	5
Nerve graft	16	18	1

Results

Schwannomas

Thirty-eight patients were males and 35 females (M : F ratio, 1.08 : 1) with an average age of 46 years (range 10-67 years). Average duration of symptoms was 5.1 years (range 6 months to 10 years). Sixty-nine patients (94.5%) presented with a palpable mass, 52 (71.2%) with pain syndromes; 14 patients had radicular pain and 38 had radicular and localized pain. Fifty-eight patients (79.4%) had referred dysaesthesia on percussion over the mass.

Table 7a. *Methods of Diagnosis; EMG and Ultrasound Findings*

	EMG			Ultrasound	
	No.	Normal	Altered	No.	Altered
Schwannomas	73	6	67	61	61
Neurofibromas	41	6	35	35	35
Plexiform neurofibromas	5	0	5	4	4

Pre- and post-operative motor deficits are reported in Table 2.

All tumours were excised completely with extracapsular excision and a nerve graft repair was performed in 16 patients, 14 of whom had sustained damage from prior operations. Tumour size ranged from 1 to 4 cm.

Two patients required re-operation along the same nerve but at a different level; in another 2 patients re-operation involved a different nerve (ulnar and median) in the same limb.

At follow-up, the motor strength of patients was 41.1% improved, 6.8% worsened, 52.1% unchanged;

Table 7b. *Methods of Diagnosis; CT Findings*

Findings	Schwannomas 73 cases	Neurofibromas 41 cases	Plexiform neurofibromas 5 cases
Pre-Contrast: hypodense	73	41	5
Post-Contrast			
None enhancement	6	3	
Homogeneous enhancement	49	27	3
Inhomogeneous enhancement	12	9	
Ring-enhancement	6	2	2

Table 7c. *Methods of Diagnosis; MRI Findings*

Findings	Schwannomas 11 cases	Neurofibromas 20 cases	Plexiform neurofibroma 1 cases
Pre-contrast:			
homogeneous	6	9	1
dishomogeneous	5	11	
Post-contrast			
homogeneous enhancement	9	11	1
inhomogeneous enhancement	3	9	

Table 8. *Size of Tumours and Operative Results*

	Schwannomas			Neurofibromas			Plexiformneurofibromas		
	Imp	Unch	Deter	Imp	Deter	Unch	Imp	Unch	Deter
0–5 cm	30	38	5	8	7	7	1		
5–10 cm				0	0	8		4	
10–15 cm				0	0	9			
15–22 cm				0	1	1			

Imp improved; *Unch* unchanged; *Deter* deteriorated;

pain syndromes had complete or partial resolution in the majority of cases (80.8%), 3 patients who had no pain pre-operatively suffered new mild pain.

Neurofibromas

Twenty-five patients were males and 16 females (M : F ratio, 1.56 : 1) with an average age of 28 years (range 12–57 years).

Twenty of the 41 patients (48.7%) had type 1 NFi 9 males and 11 females with an average age of 24 years.

The average duration of symptoms was 3.1 years (-range 6 months to 8 years). In all patients the presenting symptom was pain. Of the 41 patients, 20 (48.7%) presented with a palpable mass. Fourteen patients (34.1%) reported dysaesthesia on percussion over the mass.

Pre- and post-operative motor deficits are reported in Table 3.

Twenty-eight tumours weere excised completely and a nerve graft repair was performed in 18 of them; 13 (31.8%) tumours were excised subtotally. The size of the tumour ranged from 1 to 22 cm.

Eleven patients, all suffering from NF, were found to have multiple discrete tumours along a single nerve. Three patients required re-operation along the same nerve but at a different level and 8 patients (19.5%) required re-operation at the site of the original lesion after a mean interval of 18 months (range 9–76 months). At follow-up, the motor strength of

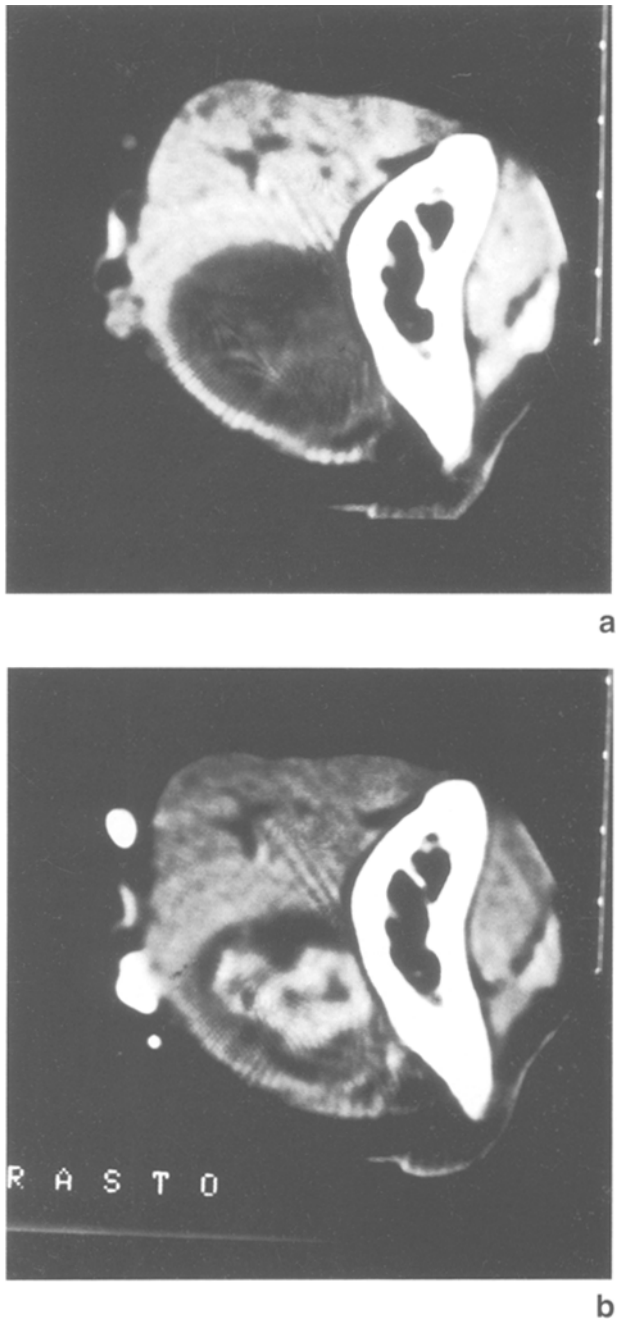

Fig. 1. (a,b) CT scan of neurofibroma of the right median nerve: tumour with lower attenuation (a) than surrounding muscles, heterogenously enhanced (b) by contrast medium

patients was 19.5% improved, 19.5% worsened, and 61% unchanged; pain syndromes had complete or partial resolution in the 56% of cases, 4 patients who had no pain preoperatively suffered new mild pain.

Plexiform Neurofibromas

Three patients were males and 2 females with an average age of 26 years (range 20 to 37 years). All patients suffered from NF and accounted for 20% of the total number of patients with NF (25 cases). The average duration of symptoms was 6.1 years (range 1 to 10 years).

In 4 patients the presenting symptom was pain, while the other patient presented with a palpable mass.

Two tumours were removed subtotally and 3 subtotally with internal neurolysis. Tumour size ranged from 2 to 8 cm.

The tumour recurred in 3 patients and the time of symptomatic recurrence ranged from 8 to 25 months after treatment.

At follow-up, the motor strength of patients was 20% improved and 80% unchanged; pain syndromes had complete or partial resolution in the 20% of cases, 1 patient who had no pain pre-operatively suffered new mild pain.

Discussion

Histological Findings

Louis [30] classifies peripheral nerve tumours into 4 groups arising from Schwann cells: 1) benign schwannomas; 2) benign neurofibromas; 3) malignant neurofibro-sarcomas; 4) any of the above associated with neurofibromatosis. The plexiform neurofibroma is another type of peripheral tumour. It originates from a focal increase in the endoneural myxomatous matrix that grotesquely mimics a normal nerve. Pathological studies of benign nerve sheath tumours have shown a distinction between schwannoma and neurofibroma because the latter presents cells resembling a perineural cell or a perineural fibroblast and has a higher content of collagen or elastin. Both tumour types have been implicated as being of Schwann cell origin [19, 20, 32].

In our cases, two major histological types of benign neurinoma affected the peripheral nervous system: schwannoma and neurofibroma. Schwannoma is encapsulated and grows within the nerve sheath, whereas neurofibroma is less circumscribed and grows within the endoneural substance. However, many authors believed neurofibromas to be unencapsulated lesions, but this observation was based upon histological findings and not always upon gross appearance [45]. Although sarcomatous degeneration of a schwannoma unassociated with von Recklinghausen's disease occurs in less than 1% of cases, sarcomatous changes associated with the multiple

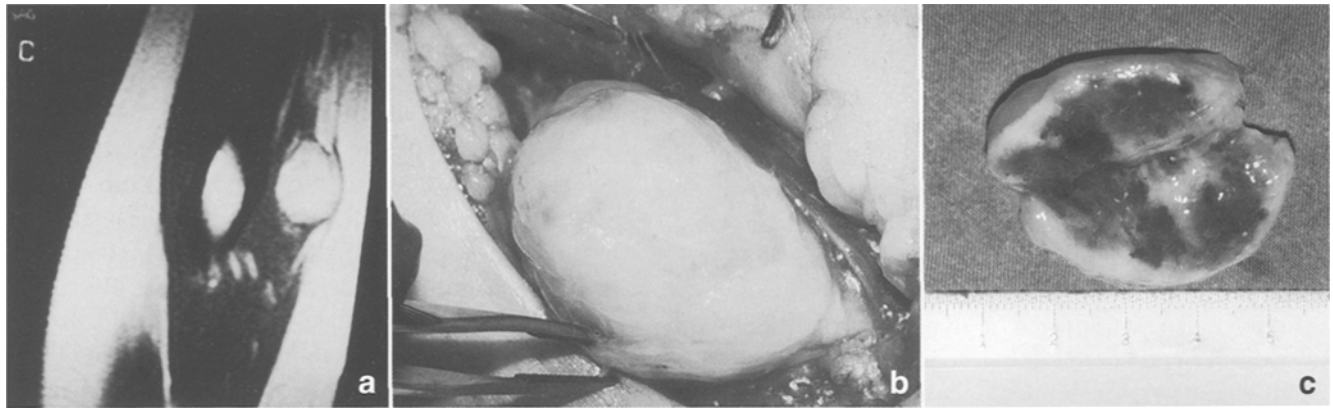

Fig. 2. (a–c) Neurofibroma of the radial nerve: MRI (a) showing, some of the radial nerve entering and exiting the tumour; operative photograph (b) showing a large tumour which originated in the radial nerve; gross specimen (c) of the tumour after total excision

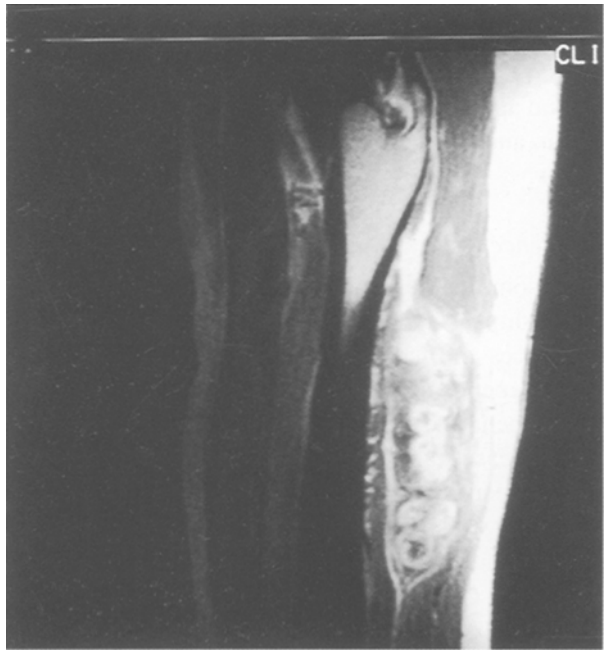

Fig. 3. Magnetic resonance T1-weighted images with gadolinium of neurofibroma of the sciatic nerve: note the cystic nature of tumour

tumours of von Recklinghausen's disease occur in 5% to 16.5% of cases [13, 15, 18].

Occurrence of multifocal schwannomas in different nerves and in the absence of NF is very uncommon [2, 3, 43]. In 1990 Tang [43], describing a personal case of multifocal neurilemmoma in different nerves in the same extremity and culled from the literature, pointed out that the principle characteristics of the 3 patients were: that all of them were male and had a long history of illness; none of them had NF; the median nerve was most frequently involved; postoperative deficits were found in all cases, probably because the chances of injuring the nerve tissue during surgery increase in proportion with the number of tumours to be excised, as the fibers or funiculi over the tumours were compressed between the neighboring tumours. We observed multifocal schwannoma (median nerve and ulnar nerve) in 2 patients not suffering from NF, both of whom presented the characteristics described by Tang [43].

Clinical Findings

These tumours are usually encountered in early or middle adult life and there is no apparent sex predilection [4, 5, 9, 14–16, 28, 33, 36, 37, 46]. Almost without exception, superficial peripheral neurinomas manifest with a mass located over the course of a nerve, mobile laterally and, less frequently, with pain and paraesthesiae. Neurofibromas more comonly present with pain, whereas in schwannomas the incidence of pain ranges from 0% to 100%. In our cases, the incidence of pain was 100% in neurofibromas in comparison to 71.2% in schwannomas. In the neurinomas of the sciatic nerve, the often prominent nocturnal exacerbation of pain could suggest the possible presence of a neoplasm [45]. The temporal evolution of the clinical syndrome allows no distiction between the different types of pelvic plexopathy and paraspinal or intraspinal root disease. In some cases, however, the highly protracted though progressive course with a long time interval between the onset of symptoms and the development of a neurologic deficit, militates against a plexus neuropathy and is equally uncharacteristic of any form of radiculopathy [7, 8, 17, 21, 34, 44].

Diagnostic Studies

The electromyogram may provide evidence of a nerve lesion if it demonstrates localized slowing or a block of conduction on stimulation of the nerve along its course, in conjunction with profuse denervation activity from needle electrode in muscles. However, if a few fibers are unaffected by the disease process, the electromyographic study may be normal [4, 16, 23], as occured in 12 (10%) of our cases. Ultrasonography, usually showed a hypo-echoic lesion with well-defined contours, but does not make it possible to identify the anatomical relationships of the tumour [21, 24, 41]. For this reason, even though it has been advocated as a diagnostic procedure of choice [24], no large series using this technique is available.

The diagnostic procedures of choice are CT and MRI [7, 10, 11, 21, 22, 24, 27, 41, 42, 44]. CT can supply information about location and type of tumour and is very effective in intrathoracic or intrapelvic and cystic tumours. On precontrast scans, the tumour appears as a homogenously hypodense soft tissue mass with smooth demarcation. On postcontrast scans, findings are variable: no enhancement, inhomogeneous, ring-formed enhancement. MRI is capable of imaging the tumour, its capsule and the nerve from which the tumour arises. The signal on T1-weighted images is usually homogeneously iso-intense, on T2-weighted images homogeneously hyperintense. Contrast enhancement is usually strong or inhomogeneous in the center of the lesion. Suh [42] thinks that the latter pattern is found only in NF. In our 32 cases (10 with NF), we did not find any differences related to the frequency of each type of enhancement among patients.

Surgical Treatment

The type of operation to be selected depends on the macroscopic nature of the tumour. The treatment of schwannomas is difficult because the natural history of untreated tumours is largely unknown and most patients present without motor deficits [1, 9, 12, 16, 24, 26, 31, 39]. The decision to operate is based largely on expected improvement of pain and the presence of space-occupying symptoms and results have usually been favourable. In our patients we performed enucleation under magnification and spared the nerve trunk in most cases; long-term results were good. In neurofibromas, the surgical approach is complex; the propensity of these tumours to grow intraneurally, infiltrating the nerves often precludes complete removal without sacrifice of part or all of the nerve, thus producing functional disability. However, neurofibromas may involve a single nerve fascicle, as observed in 3 (7.3%) of our 41 cases; in these cases, removal of this fascicle and the tumour may result in complete excision without injury to the nerve.

Our results indicate that wide excision is justifiable if the neurological deficit is severe. On the other hand, intracapsular excision and grafting give good results if the neurological deficit is mild/absent. Patients who undergo subtotal resection should be monitored at reasonable intervals to determine whether adequate relief of pain has been achieved, whether previously relieved pain is recurring, and whether CT/MRI demonstrate regrowth of the tumour.

Plexiform neurofibromas involve entire nerves with intra- and extra-fascicular growth along tissue planes, and they do not exhibit a capsule [16, 26, 28, 29, 35].Our results were unfavourable: subtotal removal appeared to provide only partial amelioration of pain, and the tumour left behind usually continued to grow.

Recurrences

For some authors [15, 17] there are no definitive relationships between histological morphology and recurrences or malignant transformation; the latter mostly depends upon other factors such as the rate of development, the size and the existence of NF [23].

In our cases, a notable difference was found in the ratio of recurrence. Single or repeated recurrences were observed in 10,9% of neurofibromas and in none of the schwannomas. Regrowth of tumours was observed in 60% of plexiform neurofibromas.

Conclusion

With the exception of plexiform tumours, benign nerve sheath tumours are removable and our results indicate that neurofibromas as well as schwannomas can be removed with an acceptable risk of injury to the nerve. This risk is greater in patients with NF, but should equally be performed in such cases in view of the possibility of malignant degeneration.

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Comment

This is a clinical research paper describing occurrence, symptomatology and the results of surgical treatment of benign neural sheath tumours, namely schwannoma, neurofibroma and plexiform neurofibroma the peripheral nerves.

The authors collected large enough material to draw some conclusions of interest to all neurosurgeons more extensive randomized research should perhaps be carried out.

T. Trojanowski

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News from the Societies

(1) The EANS Course took place in Southampton in September 1997. The next course will be held in Madeira (Portugal) where the host will be Prof. Rui Vaz (Porto).
Those who wish to participate should contact their national delegate on the Training Committee, before February 1998.

(2) The newly founded Association of Pan Arab neurological societies (see Acta Neurochirurgica Vol. 139, No. 2, 1997, p. 104) held its first meeting in Beyrouth in October 1997. Prof. Nachanakian hosted this meeting in the newly re-established city. In this particular instance, the event was twinned to the EANS-Pan Arab Course. However, in October 1999, the EANS-Pan Arab Course will be organised in its traditional form, in Tunis.