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The significance of the percentage of the defect size in spina bifida cystica in determination of the surgical technique

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Abstract *Aim:* Our aim was to classify meningoceles and meningomyeloceles in terms of defect area as a percentage of the thoracolumbar region to make it possible to select the surgical technique accordingly. *Materials and methods:* Thirty-two cases were included in the study program. Any defect smaller than 8% of the thoracolumbar region was primarily sutured and classed as grade 1. *Results:* The defects that it was not possible to handle with primary suture because of the broad base and thereby closed with muscle–skin flaps were those occupying more than 8% of the thoracolumbar region and these were classed as grade 2. It was not possible to perform primary repair of any defect occupying more than 8% of the thoracolumbar area. *Conclusion:* The use of combined latissimus dorsi+gluteus maximus muscle–skin flaps was found to be safe in broad-based meningomyelocele defects, as they provide wider closures and permanent bolstering of the meningomyelocele defect, thus protecting the region against multiple trauma.

Keywords Defect percentage · Meningocele · Muscle–skin flap · Meningomyelocele

Introduction

Spina bifida aperta, the most frequently encountered congenital central nervous system abnormality, has an incidence of 1 per 800 births [10, 12]. The meningocele and meningomyelocele defects found in 85% of spina bifida cases should be repaired soon after birth to decrease the risk of mortality and central nervous system infections, which are likely to hamper mental development [10, 18]. Mortality rates of 65–75% have been found in untreated patients in the first 6 months [8, 9], and mortality rates of 30–40% in the 1st year and 50–60% in the first 3–5 years in treated patients [9]. Despite the decrease in the mortality rate following defect closure in the early stages, coexistent central nervous system malformations, shunt complications, and genitourinary complications lower the survival rate of these patients in later stages [9]. In most cases, defects are small, so that they can be sufficiently closed by subcutaneous dissections and local flap advancement techniques. However, in 25% of the cases, the defects cannot be closed by such simple methods because they are too large [3, 14]. In such cases wide subcutaneous dissections and skin advancement techniques are needed, sometimes supplemented with lateral releasing incisions, rotation flaps, skin grafts, or muscle–skin flaps [1, 5, 9, 11, 12, 19]. Cases not eligible for primary suture have been described as 'large meningomyelocele defects' in the literature, but no objective classification system has been devised for these lesions. In this study, the area of the defect as a percentage of the thoracolumbar region was used as the basis for classification of meningoceles and meningomyeloceles, and the surgical technique to be applied was determined according to the classification allocated to each.

Materials and methods

Patients

Thirty-two cases, 16 female and 16 male neonates and babies with meningoceles and meningomyeloceles who were admitted to Firat University School of Medicine, Department of Neurosurgery between January 1995 and January 2000 were included in the study program. Seven patients had no neurological deficit, while there were 6 with paraparesis and 19 with paraplegia. Hydrocephalus was also present in 10% of the patients with meningocele and in all of those with meningomyelocele. The ages of the patients ranged from 3 days to 6 months, their weight from 2.2 to 9.5 kg, and the defect sizes from 3×4 cm to 10×15 cm (Fig. 1).

Methods

The whole body surface of each patient was calculated from the well-known formula of total body surface (m^2)={[body weight (kg)×4]+7}÷[body weight (kg)+90]. The defect area was calculated from the formula $\pi \times r^2$ (where r is the radius) for defects whose base was circular, or from the formula $(D \times d \times \pi)/4$ (where D is the long diameter and d, the short diameter) for those whose base was elliptical. The total areas of the thoracic and lumbar regions were calculated according to the "rule of nines," according to which they constitute 18% of the total body surface (Fig. 2) [13]. The percentage of the thoracolumbar region occupied by the area of the defect was calculated (Fig. 3). Defects occupying less than 8% of the area of the thoracolumbar region were classified as grade 1, and those occupying more than 8%, as grade 2.

Defects were primarily closed if the incision lips could be apposed in the midline following meningomyelocele sac removal. If the attempt at primary closure failed, a latissimus dorsi (LD) muscle–skin flap was first prepared. If this proved insufficient, a gluteus maximus (GM) muscle–skin flap was also used for closure. Patients were followed up 2 months after surgery to determine the efficiency of the technique applied in defect closure. A tissue expander was placed in one case in which the defect area covered more than 8% of the thoracolumbar region (12×16 cm), but the incision reopened when expansion occurred; since no repair was possible this patient was excluded from the study.

Operative technique

Following watertight closure of the dura, the thoracodorsal facia was opened to reach the underlying plane. LD muscles were released as far as their lateral sides at this plane overlying the paraspinal muscles. The thoracodorsal artery was secured and hemostasis was maintained. Muscles were pulled to the midline and sutured to each other. In cases with the defects close to lumbosacral area, GM muscle was also detached bilaterally from the sacral and iliac bones. The GM muscle was dissected free while preserving the superior and inferior gluteal arteries between the gluteus maximus and medius muscles. All four muscles were then sutured together in the midline. With no need for lateral releasing incisions, the skin and the subcutaneous tissue could then be approximated to each other and closure was achieved in all cases with this muscle advancement technique (Fig. 4). The patients in whom LD muscle–skin flaps were used were evaluated in terms of upper limb movements.

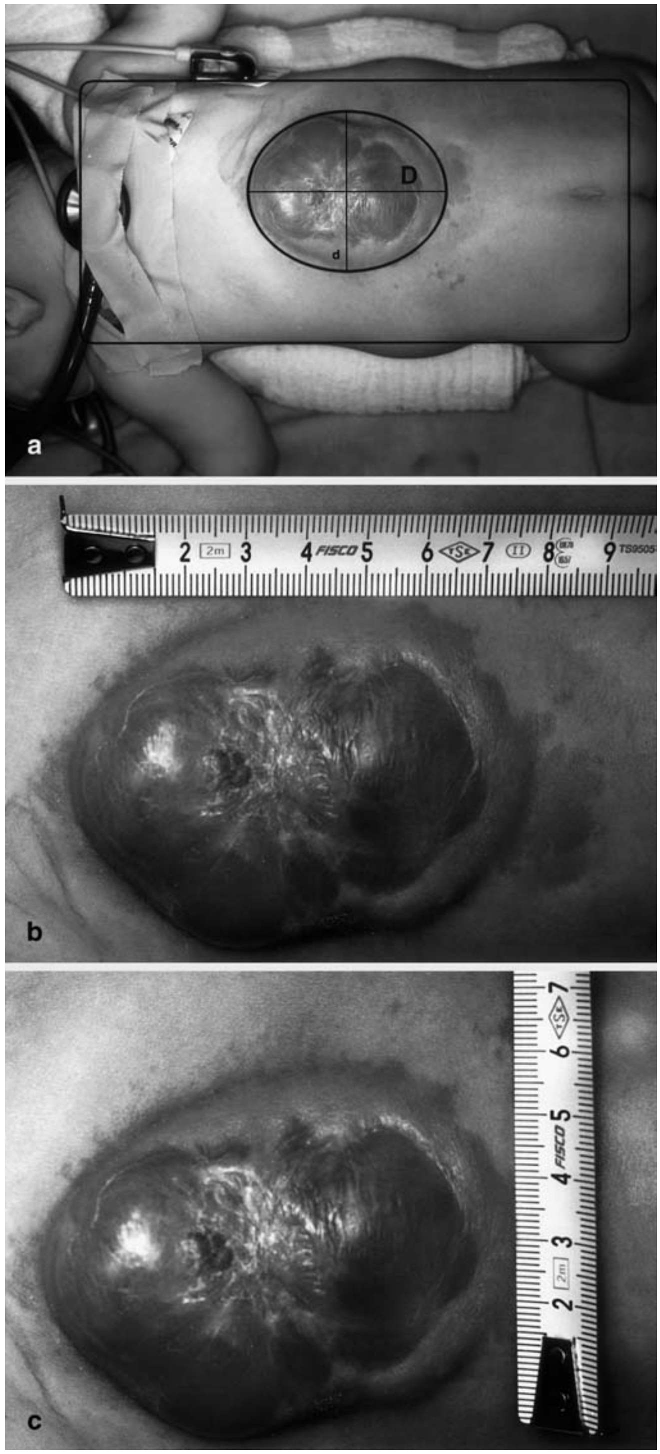


Fig. 1a–c A 6×8 cm meningomyelocele defect occupying 8.8% of the area of the thoracolumbar region in a 10-day-old patient weighing patient 3.8 kg (case 26). **a** *Black rectangle* outlines the borders of the area in the thoracolumbar region, while the *elliptical area* within it outlines the defect area. **b** Long border of the defect area measured as 8 cm, and **c** short border, as 6 cm. (*D* long diameter of defect; *d* short diameter of defect)

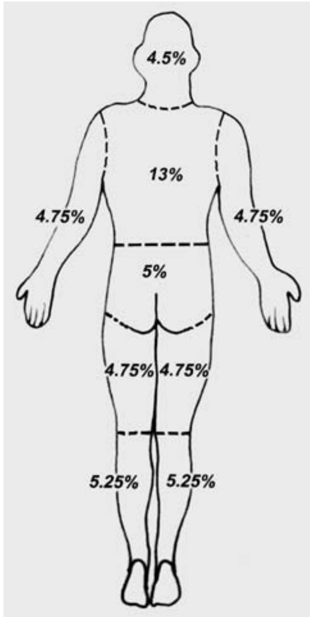


Fig. 2 Illustration demonstrating the thoracolumbar region, which accounts for 18% of the total body surface

$$\frac{\text{surface of the defect} \times 100}{\text{surface of thoracal and gluteal regions}} = \text{\% of the defect on the thoracolumbar region}$$

Fig. 3 Formula used for calculation of the percentage area of the defect in the thoracolumbar region

Results

Twenty defects were closed in a primary fashion, whereas in 8 cases thoracolumbar defects were closed with LD muscle–skin flaps and in 4 cases lumbosacral defects were closed with combined LD+GM muscle–skin flaps. Demographic information on the patients is given in Table 1. Defects occupying 8% or less of the area of the thoracolumbar region were primarily closed and were classed as grade 1, while those occupying more than 8% were closed with muscle–skin flaps and classed as grade 2.

In 3 cases out of the 20 in which primary suture was performed small parts of the incisions reopened in the early postoperative period, but this was remedied through secondary healing by means of wet dressings. One patient who had a large defect occupying more than 8% of the area of the thoracolumbar region expired from sepsis, which developed after CSF leak (case no. 3). *E. coli* colonization at the site of the incision in this case confirmed contamination via the feces. An operation was planned in 1 case with suture detachment caused by the use of a tissue expander, but was canceled since consent was not obtained from the family.

Sound and healthy soft tissue was observed overlying the dura at the late follow-up examinations of the patients (Fig. 5). No drainage catheter was used in any case. The mean operation duration was calculated as 128 min, the mean blood loss as 24 ml, and the mean volume of blood transfusion needed as 30 ml. All patients were treated with 50 mg/kg per day ceftriaxone i.v. for over 1 week after surgery since the dura had been opened. Except in the patient who had died, by the time of the follow-up 2 months after surgery, all defects were found to be entirely closed. No deterioration in the neurological status was noted in any of the patients postoperatively. There was also no movement restriction in the upper extremities of the cases treated with LD muscle-skin flaps. Patients who developed hydrocephalus were treated with ventriculoperitoneal shunt placement either at the same time or in a separate operative session.

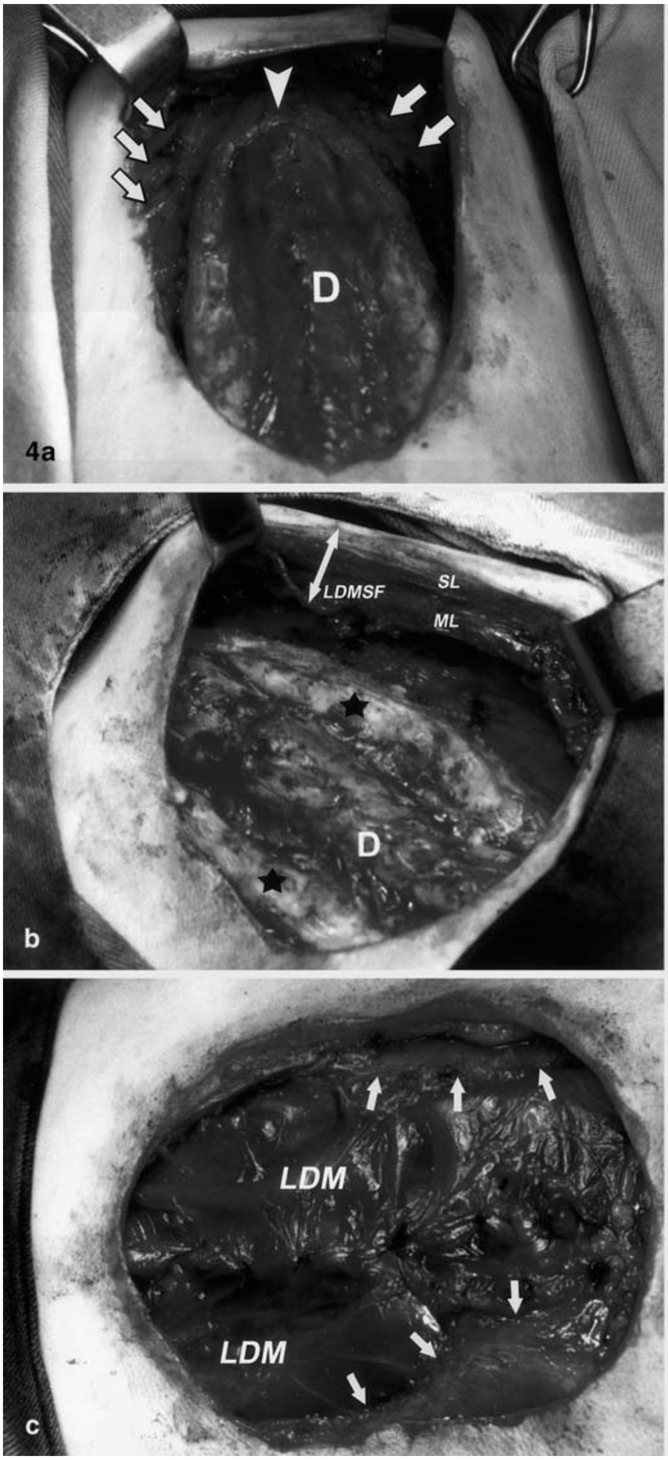
Discussion

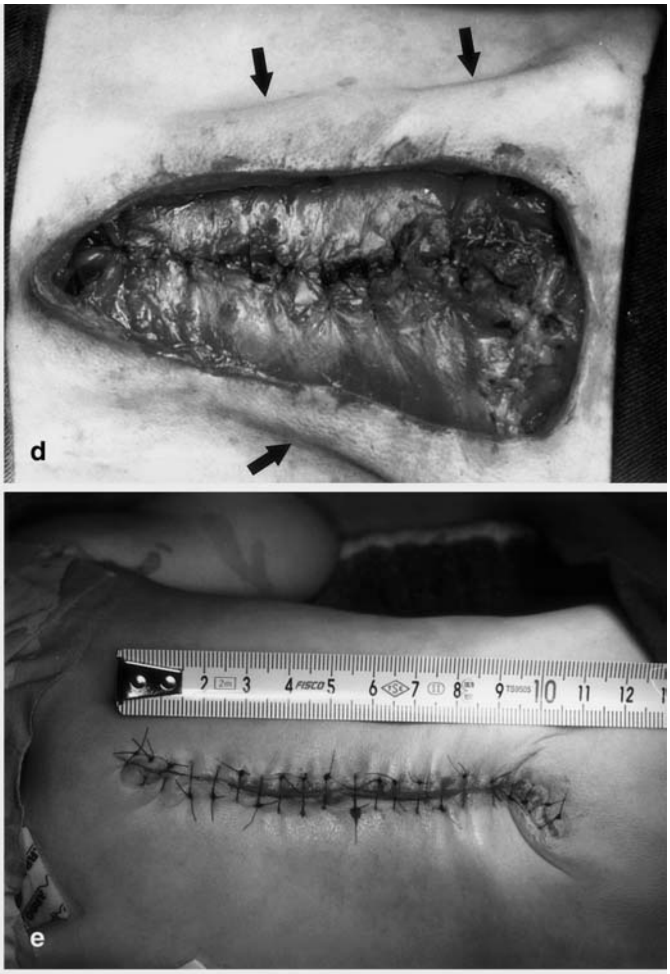
Primary closure in spina bifida cystica, i.e., spinal dysraphism cases with meningocele and meningomyelocele has been reported at rates of 75–95% [7]. This rate was calculated as 62.5% in our series. In cases in which the lesions are not eligible for primary closure the lesions are called broad-based meningomyeloceles, and supplementary techniques are required for closure in such cases [7].

At the time of broad-based meningomyelocele closure, undermining the skin combined with primary suture may cause enhanced tethering, skin necrosis, suture detachment and eventually infections [2, 8, 15]. Skin flaps such as bipediculated flaps, local transposition flaps, and Limberg-type flaps involve a 20% risk of necrosis since they require excessive undermining [15, 16, 18]. Other methods that can be used in the closure of broad-based meningomyelocele defects are the use of muscle–skin island flaps or muscle–skin flaps [10, 11, 15, 17, 18]. In the muscle–skin flap technique, after detachment of the muscle, the muscle–skin complex is pulled to the midline with or without lateral releasing incisions. Another option is to cover the advanced muscle flap with a skin graft only [6, 12, 17, 18].

Luce and Walsh [9] compared split-thickness skin grafting with the skin undermining and primary closure technique, and found the rates for wound necrosis or graft failure, sepsis, and CSF leak were 6.3% and 41%, 3.1% and 10.8%, and 6.3% and -13.5%, respectively. On the basis of these data, they advocated that primary closure, being associated with a high rate of complications should not be used in broad-based meningomyelocele defects [9]. In our series, sepsis developed as a result of CSF leak in 1 case (case no. 3) with broad-based meningomyelocele defect. Inadequate closure of the defect, which occupied 28.3% of the area of the thoracolumbar region, was thought to be the primary reason for the patient's death in this case.

The expansion of tissue expanders is another method currently in use, particularly for the repair of large defects





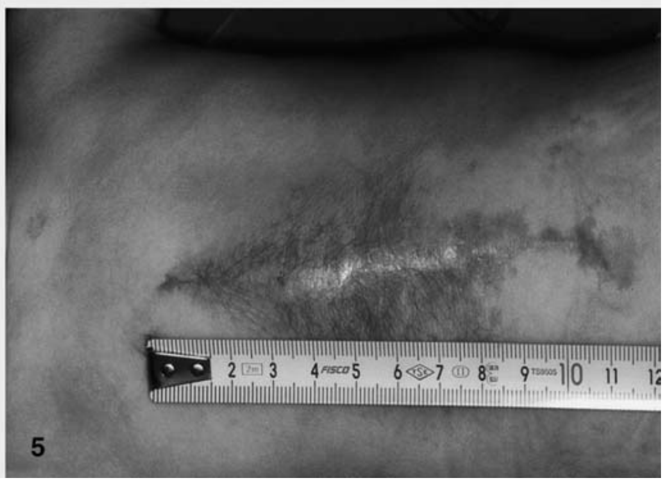


Fig. 4 **a** The upper extent to the bone (*arrowhead*) is demonstrated after removal of the meningomyelocele defect and closure of the dura mater (*D*), and the ribs (*arrows*) after elevating LD muscle. **b** LD muscle-skin flap (LDMSF) encroaching on the lateral walls of the abdomen. *SL* skin flap; *ML* muscle flap; *D* dura mater; *black stars* lateral bone borders of the myelomeningocele defect. **c** The borders of the thoracodorsal fascia (*arrows*) are exposed after having LD muscles (LDM) approached to midline. **d** After approximation of thoracodorsal fascia on the midline, the skin can also be approximated by pulling through the subcutaneous tissue on both sides (*arrows*). **e** No excessive stretching of the incision lines is observed following skin closure

Fig. 5 Scar lesion has developed by 2 months after skin closure

Table 1 Patients' weights, ages, total body areas, dorsal and gluteal region areas, defect sizes and areas, defect areas in thoracic and gluteal regions (thoracolumbar) and operation techniques (*GM* gluteus maximus, *LD* latissimus dorsi)

Case number	Body weight (kg), age	Total body surface (cm^2)	Surface of the thoracic and gluteal regions (cm^2)	Diameters of the defect (cm)	Surface of the defect (cm^2)	Surface of the defect at the thoracolumbar region (%)	Operative technique
1	9.5 kg, 6 months	4522	813	15×10	117.7	14.4	LD+GM
2	5.1 kg, 2 months	2800	504	6×8	37.6	7.4	Primary
3	5.5 kg, 5 months	3000	540	13×15	153	28.3	LD+GM
4	3 kg, 5 days	2043	367	5×7	27.4	7.4	Primary
5	3.5 kg, 9 days	2245	404	6×4	18.8	4.6	Primary
6	5.9 kg, 1.5 months	3190	574	8×8	50.2	8.7	LD
7	4 kg, 15 days	2446	440	4×6	18.8	4.2	Primary
8	3.1 kg, 7 days	2083	374	6×6	28.2	7.5	Primary
9	3.2 kg, 20 days	2124	382	5×5	19.6	5.1	Primary
10	4 kg, 2 months	2446	440	8×8	50.2	11.4	LD+GM
11	3.750 kg, 1 months	2346	422	5×3	11.7	2.7	Primary
12	3.5 kg, 1 months	2245	404	5×6	23.5	5.8	Primary
13	3.5 kg, 20 days	2245	404	5×7	27.4	6.8	Primary
14	3.6 kg, 3 days	2286	411	4×4	12.5	3.0	Primary
15	3.5 kg, 10 days	2245	404	10×6	47.1	11.6	LD
16	3 kg, 10 days	2043	367	6×6	28.2	7.7	Primary
17	3 kg, 3 days	2043	367	4×4	12.5	3.4	Primary
18	2.8 kg, 10 days	1961	352	6×14	65.9	18.7	LD+GM
19	3.6 kg, 7 days	2286	411	6×8	37.6	9.1	LD
20	3.1 kg, 7 days	2083	374	3×4	9.4	2.5	Primary
21	3 kg, 5 days	2043	367	4×6	18.8	5.1	Primary
22	3 kg, 11 days	2043	367	6×7	32.9	8.9	LD
23	3.8 kg, 2.5 months	2366	425	6×8	37.6	8.8	LD
24	3.1 kg, 5 days	2083	374	3×4	9.4	2.5	Primary
25	4 kg, 2 months	2446	440	4×4	12.5	2.8	Primary
26	3.8 kg, 10 days	2366	425	6×8	37.6	8.8	LD
27	3.5 kg, 12 days	2245	404	6×6	28.2	6.9	Primary
28	2.2 kg, 4 days	1713	308	3×4	9.4	3.0	Primary
29	4.8 kg, 1 months	2763	497	7×7	38.4	7.7	Primary
30	4 kg, 15 days	2446	440	6×8	37.6	8.5	LD
31	4 kg, 3 months	2446	440	5×10	39.2	8.9	LD
32	4.5 kg, 2.5 months	2645	476	4×4	12.5	2.6	Primary

[4]. A tissue expander was used in a case with a defect area more than 8% who was not included in the study, but the sutures reopened at the end of the 2nd week of the expansion process. This complication was thought to be due to the lacking skin and subcutaneous tissue near the expander that was to be advanced. It takes a few months to achieve an improvement of skin–subcutaneous tissue by means of a tissue expander; meanwhile, the size of the defect, although unchanged in absolute terms, will be relatively smaller owing to the weight gain and ageing by the end of the stage, and relatively more skin and subcutaneous tissue will be gained with the expander than expected. However, it may be crucial to await the increase in surface area to avoid suture detachment such as occurred in the case mentioned above.

The dorsal and gluteal regions in which meningoceles and meningomyeloceles are located make up 18% of the total body surface area [13]. Luce and Walsh [9] reported that a defect that was a mean of 22.7 cm^2 in area could be primarily closed, while those with mean areas of 37.3 cm^2 area needed skin grafting for closure. In our series, 18 cases out of the 20 whose mean defect area was found to be 20 cm^2 were closed by primary procedures. In 2 cases primary closure of defects 37.6 (case no. 2) and 38.4 cm^2 (case no. 29) was obtained. Though large, these defects, which would usually have required graft covering in the Luce and Walsh series, could be primarily closed because they occupied less than 8% of the surface area of the thoracolumbar region. In our series, defects in the cases in which primary closure proved possible were found to occupy only 8% of the surface area in the thoracolumbar region and were hence classed as grade 1. Those occupying more than 8% of the surface area were repaired by midline advancement of either bilateral LD muscle-skin flaps or combined bilateral LD+GM muscle-skin flaps, particularly in the case of defects close to the sacral region. We believe that combined LD+GM muscle–skin flaps are more resistant to multiple trauma, since they can cover larger areas and provide permanent bolstering of the meningomyelocele defect. Defects covering more than 8% of the surface area and not suitable for primary closure were considered as broad-based meningomyelocele defects as previously reported in the literature, and hence classed as grade 2. This kind of classification is practical, since it provides significant information when the percentage area of the defect in the dorsal and gluteal region is calculated and thus an idea about whether or not it will be eligible for primary closure.

Moore [12] used muscle–skin flaps in association with lateral releasing incisions in 19 patients with broad-based meningomyelocele defects, and only in 1 of these cases (5.2%) did skin necrosis develop as the result of insufficient blood supply. He stressed the use of lateral releasing incisions together with muscle skin flaps in the repair of broad-based meningomyeloceles. However, in our series, the lateral releasing procedure was not used in any of the patients. Suturing the muscles to each other made it possible to appose the skin edges in the midline without causing stretching and to achieve primary closure in all cases (Fig. 3). In 3 cases minor detachments were observed at the suture line, but these healed in the course of time with wet dressings.

The prognosis is excellent in patients with meningocele cases as there are no neurological deficits and the relatively small defect area renders it amenable to primary closure. In our series we were able to close all meningocele defects in a primary fashion.

The vascular supply to LD and GM muscles is maintained by both muscle pedicles and segmental arteries from the paraspinal region [15]. During muscle–skin flap preparation, nourishing vessels may be damaged at the time of the muscle releasing procedure and the function of the related muscle may then be violated [10]. Since muscles are released only from the paraspinal region, only segmental arteries can be damaged. In such cases, the major vascular supply to the flap will be provided via the pedicle [15]. Some authors believe that even the use of LD flaps in paraplegic patients will not hamper upper extremity functions that will be more important later in their lives [6, 17]. It has been reported that the use of this muscle in defect repair in paraplegic patients would not cause function loss during GM muscle–skin flap preparation, since this muscle is detached from both iliac crests [17].

VanderKolk et al. [17] mentioned a potential increase in the rate of scoliosis due to LD muscle malfunction in cases of myelodysplasia repaired with reverse LD flaps. However, in our cases, LD muscle was only advanced without rotation (reversing) in its normal anatomical plane of attachment with the corresponding vertebrae. Thus, muscle function is preserved and scoliosis is likely to be encountered much less frequently.

Luce and Walsh [9] reported that skin grafts were superior, since loss of 64–100 ml blood loss (30% of the circulating blood) and prolongation of the operation were noted during reverse and advancement flap application. However, the use of electrocautery in muscle–skin flap dissection and meticulous hemostasis have been reported to decrease the blood loss [17]. Ramasastry et al. [14] reported blood loss of less than 20 ml, obviating the need for blood transfusion, in their series of 9 patients who underwent LD+GM muscle–skin flap repair. In our series, the mean blood loss was 24 ml, which is 8–20% of the total circulating blood. All patients received blood transfusions. The mean volume of blood given by transfusion was calculated as 30 ml.

Conclusion

In our series it was possible to achieve primary closure of defects occupying less than 8% of the total body area in the thoracolumbar region. Those occupying over 8% were repaired by advancing either bilateral LD muscle–skin flaps or bilateral GM+LD muscle–skin flaps (particularly in the case of defects close to the sacral region) to the midline. Hence, defects occupying under 8% of the total body area in the thoracolumbar region were classified as grade 1, and those occupying over 8%, as grade 2. Combined LD+GM muscle–skin flaps were found to be useful in the repair of broad-based meningomyelocele defects, since they allow closure of larger areas and more resistance against multiple trauma as they maintain permanent cushioning in the region.

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References

1. Bannister BCM (1972) A method of repair of myelomeningoceles. Br J Surg 59:445–448
2. Celebiler O, Ozek E, Tezel E, Gurunoglu R, Ozek M, Numanoglu A (1994) Use of muscle flaps for primary closure of defects left after resection of meningomyeloceles (in Turkish). Turk Plast Cer Derg 2:136–141
3. Davies D, Adendorf DJ (1977) A large rotation flap raised across the midline to close lumbosacral meningomyeloceles. Br J Plast Surg 30:166–168
4. Frykberg T, Olsen L (1990) Tissue expansion facilitates operation of large myelomeningoceles. Z Kinderchir 45:242–244
5. Habal MB, Vries J (1977) Tension free closure of large meningomyelocele defects. Surg Neurol 8:177–180
6. Hayashi A, Maruyama Y (1991) Bilateral latissimus dorsi V-Y musculocutaneous flap for closure of a large meningomyelocele. Plast Reconstr Surg 88:520–523

7. Humphreys RP (1996) Spinal dysraphism. In: Wilkins RH, Rengachary SS (eds) Neurosurgery. McGraw Hill, New York, pp 3453–3464
8. Laurence KM (1974) Effect of early surgery for spina bifida cystica on survival and quality of life. Lancet I:301–304
9. Luce EA, Walsh J (1985) Wound closure of the myelomeningocele defect. Plast Reconstr Surg 75:389–393
10. McCraw JB, Penix JO, Freeman BG, Vincent MP, Wirth FH (1987) Soft tissue repair of myelomeningocele defects using bilateral latissimus dorsi and trapezius musculocutaneous flaps. Ann Plast Surg 18:147–155
11. McDevitt NB, Gillespie RP, Woosley RE, Whitt JJ, Bevin AG (1982) Closure of thoracic and lumbar dysgraphic defects using bilateral latissimus dorsi myocutaneous flap transfer with extended gluteal fasciocutaneous flaps. Childs Brain 9:394–399
12. Moore TS, Dreyer TM, Bevin AG (1984) Closure of large spina bifida cystica defects with bilateral bipedicled musculocutaneous flaps. Plast Reconstr Surg 73:288–292
13. Press B (1997) Thermal, electrical and chemical injuries. In: Aston SJ, Robert WB, Charles HMT (eds) Grabb and Smith's plastic surgery. Lippincott-Raven, Philadelphia, pp 161–191
14. Ramasastry SS, Ramirez OM (1990) Bilateral interconnected latissimus dorsi-gluteus maximus musculocutaneous flaps for closure of large lumbosacral meningomyelocele defects. In: Strauch B, Vasconez LD, Hall-Findlay EJ (eds) Grabb's encyclopedia of flaps. Little, Brown, Boston, pp 1383–1387
15. Ramirez OM (1987) A new surgical approach to closure of large lumbosacral meningomyelocele defects. Plast Reconstr Surg 80:799–807
16. Schleflan M, Merhof AI, Ward JD (1984) Meningomyelocele closure with distally based latissimus dorsi flap. Plast Reconstr Surg 73:956–959
17. VanderKolk CA, Adson MH, Stevenson TR (1981) The reverse latissimus dorsi muscle flap for closure of meningomyelocele. Plast Reconstr Surg 3:454–456
18. Zide BM (1990) Spina bifida. In: McCarty JG (ed) Plastic surgery. Saunders, Philadelphia, pp 3780–3796
19. Zook EG, Dzenitis AJ, Bennet JE (1969) Repair of large myelomeningoceles. Arch Surg 98:41–43