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Practical Review of the Comprehensive Management of Morel-Lavallée Lesions

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Background: Morel-Lavallée lesions have been described in the literature since the mid-19th century, yet contemporary clinical management continues to be challenging and remains variable. These closed degloving injuries are usually seen in the setting of blunt trauma and are due to shearing forces, creating a space for the collection of hemolymphatic fluid. These fluid collections can be persistent despite conservative treatment attempts and can require staged surgical interventions.
Methods: A literature search of peer-reviewed articles pertaining to Morel-Lavallée lesions was performed. Articles relating to the pathophysiology, clinical presentation, diagnosis, treatment, and management of complications of Morel-Lavallée lesions were included to formulate recommendations for clinical management.
Results: Fifty-six relevant articles were included in the review. Recognition of these lesions may be delayed and the use of imaging is important in diagnosis. Initial attempts at conservative management may be appropriate for smaller, uncomplicated Morel-Lavallée lesions. Surgical interventions such as open debridement, techniques to close dead space, negative pressure wound therapy, and skin grafts or flaps are critical to managing complex or recurring lesions. An algorithm for the treatment of Morel-Lavallée lesions is proposed based on review of the literature.
Conclusions: Plastic and reconstructive surgeons are frequently involved in more complex Morel-Lavallée lesions such as those exhibiting delayed healing or super-infection. The skillset needed for successful management of patients with Morel-Lavallée lesions is well within the armamentarium of plastic and reconstructive surgeons. *(Plast Reconstr Surg Glob Open 2021;9:e3850; doi: 10.1097/GOX.0000000000003850; Published online 7 October 2021.)*

INTRODUCTION

Morel-Lavallée lesions (MLLs) were first described by Dr. Maurice Morel-Lavallée in the mid-19th century after observing a subcutaneous fluid collection in a patient who had fallen off a train.[1] In the current literature, the term MLL describes a closed degloving injury where hypodermis and skin are sheared from the underlying deep fascia with subsequent accumulation of fluid in this newly created space.[2] Despite the frequency of traumatic injury, these lesions are uncommon. One retrospective study at a trauma center reported 79 cases in an eight-year period, with an estimated incidence of 0.7% of motor vehicle collisions (MVC).[3] Specific types of injuries may be more highly correlated with MLLs—for example, one 2016 study found 12.2% of pelvic fractures to have an associated MLL.[4]

Despite their relative rarity, Morel-Lavallée lesions are notoriously difficult to treat. Lesions can be chronic, refractory to multiple interventions, plagued by infection, and cause poor functional and cosmetic outcomes. Plastic surgeons are frequently part of the multidisciplinary team treating patients with these complex lesions. This practical review focuses on the pathophysiology, clinical presentation, diagnosis, classification, treatment, and complications of MLLs.

METHODS

A PubMed search was performed using the term "Morel-Lavallée." Article titles and abstracts were individually reviewed to ensure they pertained to the topic of Morel-Lavallée lesions or closed soft tissue degloving injuries. Additional articles were investigated from cited references. Articles were included if they provided information

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on pathophysiology, clinical presentation, diagnosis, or treatment. Articles were excluded if they were duplicates, not written in English, or did not pertain to clinical management.

RESULTS

The PubMed search returned 239 results. After manually reviewing these results, 56 articles were deemed relevant for inclusion and quantitatively analyzed for content (Fig. 1). Information was summarized and organized to provide a comprehensive review and to create a management algorithm for Morel-Lavallée lesions.

DISCUSSION

Pathophysiology

A Morel-Lavallée lesion is the result of a closed degloving injury causing an acute separation of the superficial epidermal and hypodermal layers from the deeper fascia. This leads to disruption of the intervening microvasculature and lymphatic channels, with subsequent accumulation of blood and lymphatic fluid. When this fluid accumulation is not recognized in the acute setting, an organized pseudocapsule may form around it. This pseudocapsule develops due to hemosiderin deposition along the walls of the fluid collection as the hemolymphatic fluid is absorbed.[5] This initially sterile fluid collection may also become secondarily infected, leading to a closed space infection similar to an infected seroma or abscess.[6]

Clinical Presentation

Morel-Lavallée lesions should be considered in any patient with a mechanism of injury causing shear trauma. High-energy motor vehicle collision is a common cause of MLL, although crush injuries and low velocity blunt mechanisms such as falls are commonly implicated. Sports-related MLLs with these same mechanisms are described in a number of series and case reports.[7–12]

Lesions typically present within hours-to-days after trauma; however, up to one-third of cases present months-to-years later and may be difficult to associate with a specific inciting event.[13] Clinical presentation can range from obvious external soft tissue damage with edema, ecchymosis, and epidermal or dermal injury, to no outward signs of underlying tissue trauma. Patients presenting acutely often have soft, fluctuant areas of swelling associated with ecchymosis, skin hypermobility or firmness, and pain.[6] In one report, an MLL presented as hypovolemic shock and a "boggy" posterior trunk, which was confirmed on computed tomography (CT).[14] The volume of accumulated blood can be significant and impending pressure necrosis of the overlying skin must be recognized.

MLLs may also become secondarily infected, presenting with overlying soft tissue cellulitis or conversion of the closed sterile fluid collection to an abscess. Chronic presentations may involve lack of resolution of soft tissue swelling after an inciting trauma or capsule formation on imaging.[5]

While MLLs may occur anywhere subjected to shear forces, several locations of the body have higher likelihood of developing MLLs. These include the knee, greater trochanter, and anterolateral compartment of the

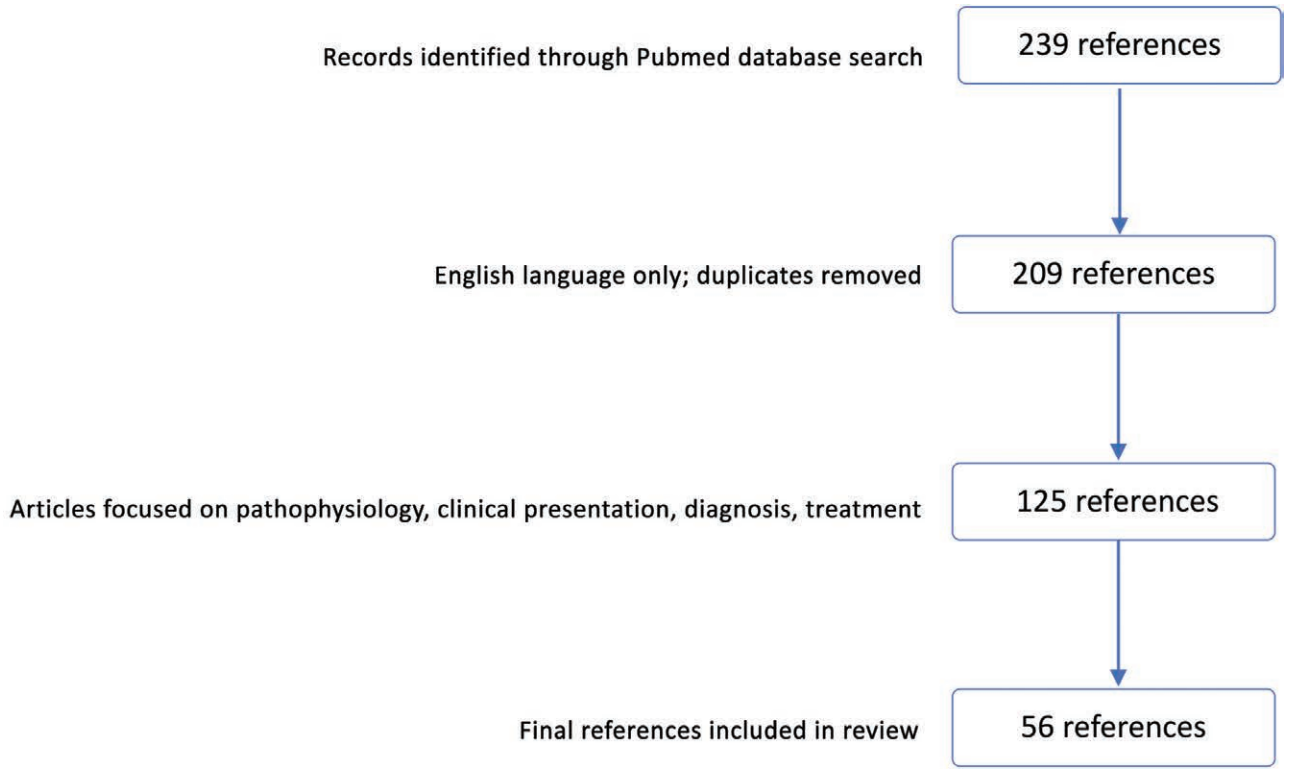

Fig. 1. Process of article inclusion.

thigh due to greater mobility of the dermis and subcutaneous tissue, allowing a more dramatic propagation of shear forces.[15] Nickerson et al performed a retrospective review of patients presenting to a major trauma center and found 64% of MLLs presented in the lower extremity[3] (Table 1). MLLs in the calf, abdominal wall, proximal upper extremity, lumbar spine, scalp, periscapular, and sacrococcygeal regions are also described.[16–20]

Distinction has been made between adult and pediatric presentations of traumatic MLLs. Adults have higher occurrences of hip and thigh lesions, whereas children more often present with lesions at the knee and distal lower extremity.[21] Pediatric patients are notably unreliable in reporting timing of trauma and symptom onset, making diagnosis difficult. Nonaccidental trauma must also be part of the differential diagnosis in pediatric patients considering the high energy needed to incur these lesions.[22]

Diagnostic Imaging

Imaging is an important adjunct in the diagnosis of MLLs. Differential diagnoses include seroma, abscess, and solid soft tissue masses or tumors.

Ultrasound is frequently used to assess subcutaneous or supra-fascial fluid collections and is relatively low cost. Sonography often shows a heterogeneous, compressible fluid collection between the subdermal fat and fascia (Fig. 2).[13] MLLs often become homogenous over time secondary to liquefaction. The sensitivity and specificity of ultrasound varies due to differing characteristics of the lesions as they evolve. Neal et al found that all hip and thigh MLLs imaged with ultrasound were located between the deep fat and fascia; however, the echogenicity, shape, margin quality, and homogeneity were highly variable. In their series, 60% of lesions were fusiform, 25% were flat, and 15% were lobulated.[23] Other types of lesions such as neoplasms, hematomas, abscesses, and fat necrosis may have similar appearances and should be considered in the differential diagnosis.[2]

CT is often responsible for the initial diagnosis of an MLL, especially in the trauma patient undergoing imaging of multiple body regions. Contrast-enhanced CT may show extravasation of blood within a closed space in the acute phase, or a fluid collection with a lower density than simple hematoma in the subacute phase (Fig. 3).[13,24]

Table 1. Incidence of Morel-Lavallée Lesions by Body Region—Experience from a Major Trauma Center*[3]

Location	Total (n = 87)	Recurrence**	Underlying Fracture**	High-energy Mechanism**
Thigh	28 (32)	8 (29)	12 (43)	21 (75)
Flank	15 (17)	4 (27)	6 (40)	7 (47)
Hip	14 (16)	2 (14)	6 (43)	6 (43)
Knee	9 (10)	1 (11)	1 (11)	5 (56)
Back	9 (10)	4 (44)	3 (33)	5 (56)
Shin/calf	5 (6)	1 (20)	1 (20)	3 (60)
Abdomen	2 (2)	1 (50)	1 (50)	1 (50)
Shoulder	2 (2)	0	0	1 (50)
Elbow	2 (2)	0	0	0
Chest	1 (1)	0	0	0

*Values are number of lesions (%).
**Percentages are based on the total lesions at that location.
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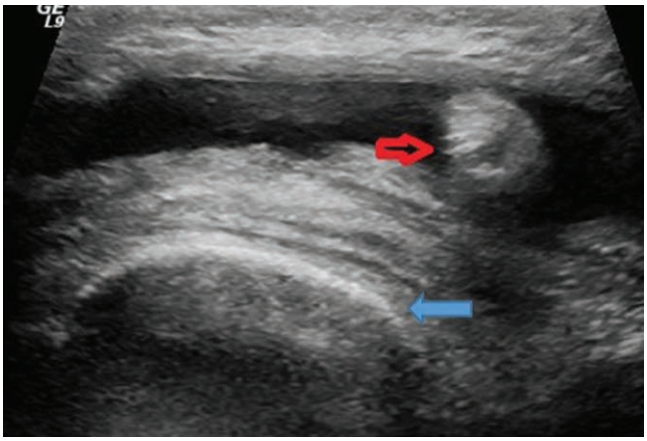

Fig. 2. Transverse grayscale sonographic image demonstrates a predominantly anechoic fluid collection in the subdermal region, overlying the greater trochanter (blue arrow). An internal area of echogenicity is seen with partial distal acoustic shadowing, corresponding to a sheared area of subdermal fat within the hemolymphatic fluid collection (red arrow).[13] Reprinted with permission from Elsevier Science & Technology Journals.

CT can show the presence or absence of a lesion or fluid collection, but the composition, or density, may be better investigated with other imaging modalities.[5] It is important to be cognizant of the possibility of MLLs in acute trauma patients, as one study reported 25% of MLLs were not mentioned in CT findings yet were clinically present. Lesions may be reported as "hematoma" in the acute stage, and "fluid collection" in the subacute stage.[24]

Magnetic resonance imaging (MRI) may be better suited for complicated Morel-Lavallée lesions. Compared with CT, MRI can better define fluid density, differentiate between solid masses, and give detail on extra-compartmental spread and surrounding soft tissue characteristics (Fig. 4). Subacute MLLs exhibit high T1 and T2 signaling, whereas chronic MLLs exhibit intermediate T1 and heterogeneous T2 signals.[15] MRI may be more useful in patients with MLLs surrounding joints, which can better characterize the location of fluid collections and detail adjacent anatomy.[10] The sensitivity and specificity of ultrasound, CT, and MRI for Morel-Lavallée lesions has not been specifically reported, and further studies are needed to better characterize these imaging modalities (Table 2).

Classifications

Classifications of Morel-Lavallée lesions have been proposed based on various factors, such as chronicity, the presence or absence of a pseudocapsule, and imaging characteristics. Carlson et al describe a classification based on chronicity of lesions relative to the time of injury; lesions less than 3 weeks old are considered acute, and those more than 3 weeks are chronic.[25] Shen et al. describe lesions based on the presence or absence of a pseudocapsule.[26] Mellado and Bencardino are the only authors to have published a formal classification of MLLs, which is based on MRI characteristics[27] (Table 3). Although these classifications may be helpful in organizing treatment planning, none are standardized.

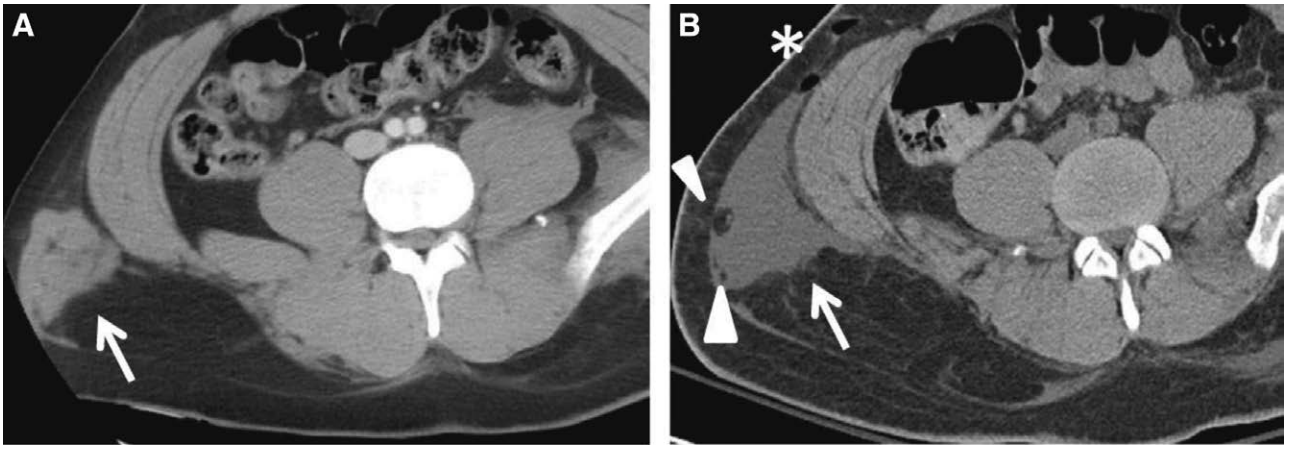

Fig. 3. Scans of a 34-year-old woman who had been in a motor vehicle accident. A, Initial contrast-enhanced CT of the abdomen and pelvis performed within 12 h of the initial trauma demonstrates a heterogeneous hyperdense lesion of nonorganized, irregular-shaped, poorly marginated blood products in the right flank region in the deep subcutaneous tissues (arrow). B, Two days later, axial unenhanced CT demonstrates a more well-defined, partially marginated, closed internal degloving lesion (arrow) with internal fluid attenuation and small internal fat globules (arrowheads). The lesion had increased in size in the interval. Two small locules of gas are seen anteriorly, indicating suspected infection (adjacent to the asterisk in B). The lesion was later debrided and necrotizing fasciitis was found extending to the perineal region.[24] Reprinted with permission from Springer Nature BV.

Treatment of Morel-Lavallée Lesions

Treatment of Morel-Lavallée lesions may be conservative, minimally invasive, or surgical. The choice of treatment may depend on timing of diagnosis, size and complexity of the lesion or soft tissue injury, superimposed infection, or the presence of other adjacent injuries. Because MLL is most frequently seen in the trauma patient, the overall clinical status must also be taken into consideration, especially in unstable or elderly patients unable to withstand multiple interventions.

Conservative

Morel-Lavallée lesions may be observed in cases of small fluid collections where no overlying pressure changes occur. Compression is often used to decrease and control dead space.[1] Trialing compression may be appropriate in the unstable patient. In one report of a posterior trunk MLL, supine positioning and compression using the patient's body weight successfully tamponaded the lesion.[14] The risk of pressure ulceration secondary to continuous bedrest should be considered with this approach. Additionally, observation carries a risk of vascular compromise to overlying tissue if there is pressure-related ischemia from the accumulated fluid.[1,28]

Minimally Invasive

In patients who fail conservative measures or those requiring immediate intervention, minimally-invasive approaches may be appropriate. Direct or image-guided aspiration using CT or Ultrasound is commonly used.[11,12,17,29–31] Large bore needles are recommended for aspiration of thick fluid found within these lesions.[7] Drainage catheters, typically ranging from 12 to 14 French, are frequently left in place to allow continued egress of fluid and can serve as a conduit for introduction of sclerosing agents. Catheters and drainage tubes may be left

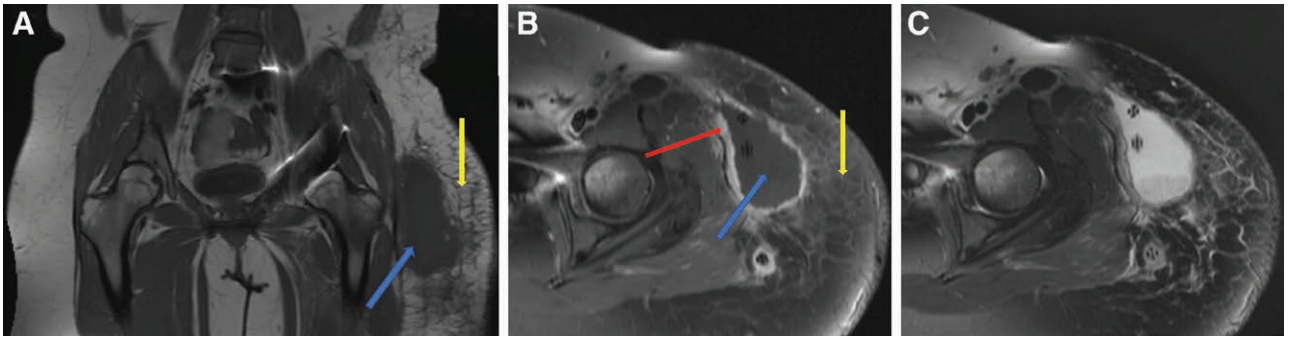

Fig. 4. MRI with and without contrast of left hip Morel-Lavallée lesion persisting 6 months after motor vehicle collisions with associated pelvic fracture. A, Coronal T1-weighted image of left hip Morel-Lavallée lesion (blue arrow) with surrounding subcutaneous edema (yellow arrow). B, Contrast-enhanced axial T1-weighted fat-suppressed image showing chronic lesion with thick, irregular, enhancing rim (red arrow) surrounding fluid collection (blue arrow). Two drainage catheters are seen traversing the fluid collection, and a third is shown inferiorly within a collapsed cavity. Note the surrounding subcutaneous edema and stranding suggestive of cellulitis, which this patient did display clinically. C, Axial T2-weighted image of the same lesion.

Table 2. Imaging of Morel-Lavallée Lesions

Modality	Relative Cost	Description	Sensitive	Specific	Pro	Con
Ultrasound	Low	Heterogeneous, compressible fluid collection	Yes	No	No radiation exposure	Operator-dependent
Computed tomography	Moderate	Extravasation of blood components into contained space (acute); fluid collection with lower density than simple hematoma (subacute)	Yes	No	Fast, often done for other traumatic injuries	Radiation exposure
Magnetic resonance imaging	High	High T1, T2 signaling (subacute); intermediate T1, heterogeneous T2 signaling (chronic)	Yes	Yes	No radiation exposure; provides high detail of soft tissue	Time-consuming

externalized, or connected to closed drainage systems and placed to gravity, bulb, or wall suction.[32–35] Compression garments serve as an adjunct after aspiration to prevent re-accumulation of fluid.[17]

Chronic MLLs with well-developed pseudocapsules have higher likelihood of recurrence after aspiration and compression.[1,3,9,26] Pharmacologic sclerosing agents may be used to create a local inflammatory response to promote apposition of the cavity walls, thereby preventing recurrence of fluid accumulation. In one study of 16 patients who had failed simple aspiration therapy, all had complete resolution after doxycycline sclerodesis and subsequent compression.[36] Other sclerosing agents that have been used with success include erythromycin, bleomycin, absolute alcohol, vancomycin, tetracycline, and talc.[5,37] Applying compression after sclerodesis is critical and may determine ultimate success of this minimally invasive option.[36]

Surgical

While acute lesions may be managed with compression, aspiration, and/or injection of sclerosing agents, the pseudocapsule seen in chronic MLLs makes these management strategies less effective and prone to recurrence.[9] MLLs frequently require surgical intervention, especially with large lesions, those that are recurrent, or with overlying soft tissue compromise. Debridement of any devitalized tissue is critical to effective management.[6] In the case of massive soft tissue loss, skin grafts or local flap-based reconstruction may be required.[20,22,38–41]

In chronic MLLs with intact overlying soft tissue and a pseudocapsule, open total capsulectomy is recommended to decrease or prevent recurrence of fluid accumulation.[6,26,42] Operative techniques such as progressive tension sutures and quilting are especially useful in the reduction of dead space, and may be performed with a variety of strong suture material.[43–47] Closed suction drains are advised to prevent re-accumulation of fluid.

Pharmacologic adjuncts such as fibrin sealant may help promote apposition of cavity walls and closure of dead space after operative debridement and direct capsule excision.[8,48] Studies on the use of fibrin products in MLLs are limited to small series and would benefit from additional investigation regarding efficacy.

Negative pressure wound therapy can be used as an initial treatment option in cases requiring staged operations. Negative pressure wound therapy is effective in mechanically decreasing dead space and promotes vascular ingrowth at the site of sponge contact. Black foam sponge or a sponge with instillation capabilities is inserted into the cavity to help maintain a sterile environment between operations and allow for revascularization and eventual apposition of cavity walls, thereby avoiding significant overlying soft tissue loss that may occur with open debridement. Negative pressure wound therapy may also be employed as a bridge to delayed primary closure or skin grafting in patients with significant overlying soft tissue damage.[3,38,40,49,50]

The use of liposuction cannulas has been described in directly disrupting the MLL cavity. In one report, a 3 mm liposuction cannula was used to directly aspirate the substance of the capsule and contained fat, which effectively reduced the size of the lesion with no reported recurrence at 6 weeks.[51] Liposuction has also been used to improve the appearance and contour of the surrounding soft tissue.[52]

Video-assisted endoscopic debridement is another technique that allows for direct visualization and excision of a capsule. Endoscopic debridement has also been combined with percutaneous cutaneo-fascial sutures to reinforce closure of dead space. This technique has been used in patients with comorbidities that preclude open debridement and drainage, and may also be better suited to those requiring expedited recovery such as young athletes.[8,47,53]

To address a possible lymphatic contribution to MLLs, injectable blue dye has been utilized to locate lymphatic

Table 3. MRI Classification of Morel-Lavallée Lesions[27]

	Type I	Type II	Type III	Type IV	Type V	Type VI
	Seroma	Subacute Hematoma	Chronic Organizing Hematoma	Closed Laceration	Pseudonodular	Infected
Morphology	Laminar	Oval	Oval	Linear	Round	Variable sinus tract
Capsule	Occasional	Thin	Thick	Absent	Thin/thick	Thick
T1 signal	Hypointense	Hyperintense	Intermediate	Hypointense	Variable	Variable
T2 signal	Hyperintense	Hyperintense	Heterogeneous	Hyperintense	Variable	Variable
Enhancement	Absent	Variable	Internal/peripheral	Variable	Internal/peripheral	Internal/peripheral

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channels that have been disrupted. Persistent lymphatic leak can contribute to refractory MLLs and with the aid of reverse lymphatic mapping, severed channels may be located and surgically ligated.[48]

Based on the reviewed literature, the authors propose an algorithm for management of Morel-Lavallée lesions based upon the chronicity, lesion characteristics, and response to therapy (Fig. 5).

Iatrogenic Morel-Lavallée Lesions

MLLs have been described postoperatively in patients undergoing cosmetic liposuction and lipoabdominoplasty. It is hypothesized that the dead space created from repeated cannulation of fatty tissue during liposuction or from elevation of skin flaps can allow for persistent fluid accumulation, especially if no postoperative compression is used.[29,54] It must be questioned whether these cases constitute true MLLs, as generally this description is reserved for shearing or degloving injuries in the trauma setting. Nevertheless, these case reports deserve mention as they specifically pertain to the plastic surgery patient.

Complications of Morel-Lavallée Lesions

Recurrence is common after initial attempts at treatment of Morel-Lavallée lesions. It is difficult to determine true recurrence rates due to the variability of data published. Studies report recurrence based on region of body, and others based on treatment. Overall, published recurrence rates ranged from 0% to 75%.[3,26,36] In one series of patients being managed conservatively, the average number of aspirations was 3.44 (range, 1–6) per patient, with an average duration of 13 months (range, 6–23).[36] In their retrospective review, Nickerson et al reported aspiration of more than 50 mL to be significantly more common among lesions that recurred (83%) versus those that resolved (33%), and may guide treatment decision-making.[3]

Infection in the form of cellulitis or abscess commonly complicates management of Morel-Lavallée lesions. Bacteria gain entry into the cavity as a result of overlying soft tissue trauma, hematologic seeding, or via surgical approach for other injuries.[5,55] In one 15-year review of the literature, the infection rate was reported to be 19% in peripelvic MLLs, and Hak et al reported a 46% positive culture rate of fluid obtained from closed MLL cavities. Reported culture results include: *Enterobacter cloacae, Acinobacter baumannii, Pseudomonas aeruginosa, Klebsiella pneumoniae, Staphylococcus epidermidis,* and *Staphylococcus aureus.*[26,55] Culture-guided antibiotic therapy is recommended, and may require prolonged treatment courses.

Delayed recognition of an MLL may put the patient at increased risk for infection and wound healing complications at the site, which may delay operative intervention of other adjacent high-risk injuries such as those requiring bony fixation.[6,56] MLLs that occur adjacent to areas requiring operative intervention for other traumatic injuries should be surgically addressed at the same time to prevent infection of these sites.[1,56]

Although chemical sclerodesis such as with doxycycline has proved to be an important technique in the

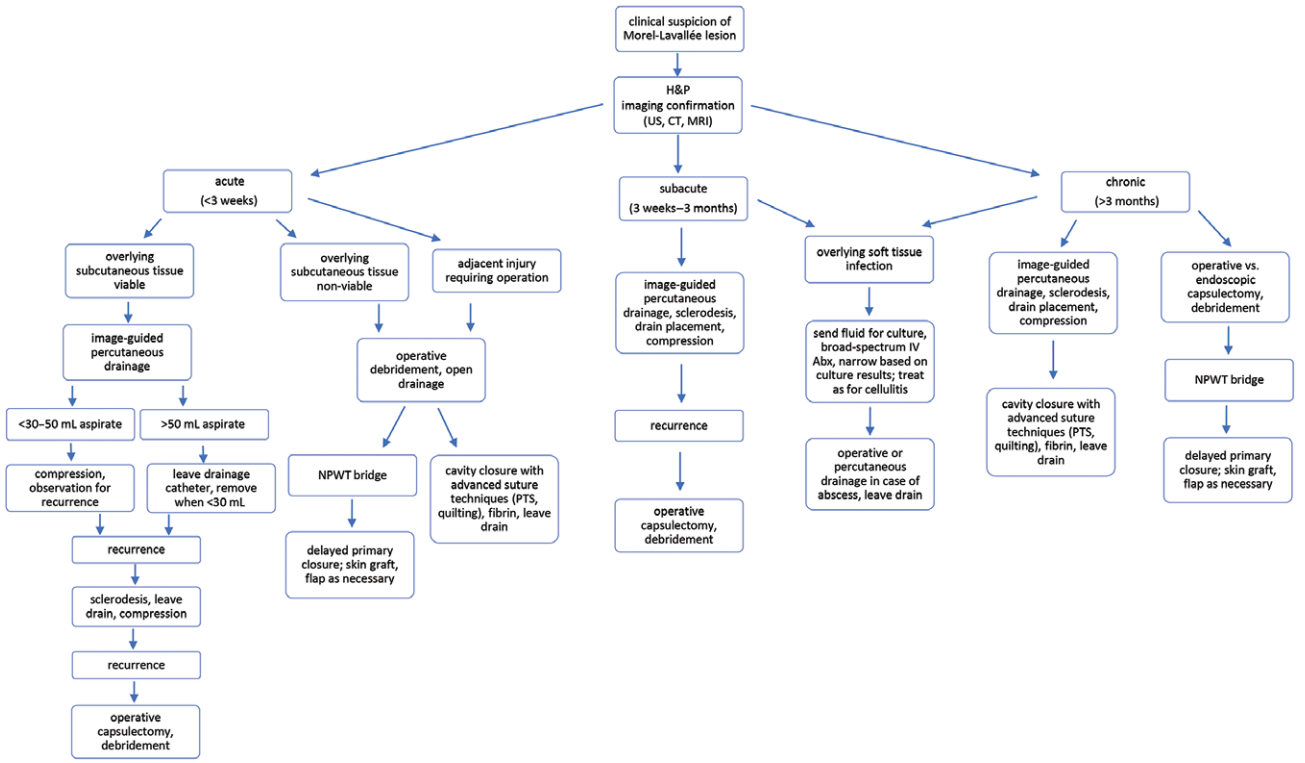

Fig. 5. Algorithm for management of Morel-Lavallée lesions.

management of MLLs, contour deformity after treatment has been reported. Bansal et al reported a series in which 18% of patients successfully treated with doxycycline sclerodesis had resultant contour deformities, which was attributed to collapse of dead space and alteration of fibrous and fatty tissue within the cavity.[36] Patients should be counseled on the risks of contour deformity during treatment planning.

CONCLUSIONS

Morel-Lavallée lesions are the result of closed degloving injuries most frequently seen in the trauma setting. Although the reported incidence is low, they may be under-recognized. The timing of recognition of these injuries affects the approach to treatment. Lesions recognized acutely may be amenable to observation, compression, or aspiration and drain placement. Recurrent or chronic lesions may require the use of sclerosing agents, serial operative debridement, in addition to more complex wound management strategies such as negative pressure wound therapy, advanced suture techniques, and reconstruction of skin and subcutaneous tissue with grafts or flaps. Plastic and reconstructive surgeons should be aware of the clinical presentation, diagnosis, and treatment, as these patients can be complicated from a wound management perspective and frequently require advanced techniques for optimal outcomes.

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