Understanding Fatal Fat Embolism in Gluteal Lipoinjection: A Review of the Medical Records and Autopsy Reports of 16 Patients

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Background: Deaths secondary to gluteal lipoinjection are relatively recent events of major importance. However, little is known in relation to their behavior and clinical evolution. Therefore, an analysis was performed of case records from clinical cases that encountered this problem, correlating the results with the findings during autopsies.
Methods: An analysis was performed of records from patients who died secondary to gluteal lipoinjection. Patient-specific data, surgical procedure, clinical picture, evolution, and outcome were analyzed. The findings of the autopsies and the involvement of other organs were also analyzed and correlated.
Results: From 2000 to 2009, 16 files were obtained that fulfilled the indicated requirements. There were no statistically significant differences in the general characteristics of the patients, such as age, body mass index, or volume lipoinjected or liposuctioned. The clinical pictures were similar in all cases, and the autopsy findings showed the presence of microembolism in all cases and macroembolism in the most severe cases.
Conclusions: The most significant parameter of severity in patients who undergo gluteal lipoinjection is the presence of fat in macroscopic form in the circulation. The volumes of liposuctioned or lipoinjected fat have little influence. Hypoxemia, hypotension, and bradycardia are the characteristic clinical features. Although there is no specific treatment, immediate aggressive vital support to attempt to stabilize the patient is crucial. (*Plast. Reconstr. Surg.* 142: 1198, 2018.)
CLINICAL QUESTION/LEVEL OF EVIDENCE: Therapeutic, V.

PATIENT SAFETY

5 THERAPEUTIC

Gluteal lipoinjection in conjunction with lipoinjection has become one of the most frequently performed procedures in cosmetic surgery to achieve improvement of the body contour.[1,2] Its frequency has been increasing yearly, making it one of the operations with the most significant growth rate in the past 10 years.[3] However, along with the increased incidence in liposuction and gluteal lipoinjection worldwide, it has also become one of the operations producing critical complications.[4–7] It has been reported that the main cause of mortality secondary to gluteal lipoinjection is the lesions in the gluteal vessels during surgery leading to absorption of injected fat into the circulation, with pulmonary and cardiac involvement.[7] However, there are no studies that help us understand the processes that occur secondary to the absorption of fat into the circulation and how they evolve to cause the deaths of these patients, which would be very useful in implementing patient management. Therefore, we conducted this 9-year research study to analyze the records of patients who died secondary to gluteal lipoinjection.

MATERIALS AND METHODS

A retrospective study was conducted, analyzing the files of autopsies performed between 2000

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and 2009 in patients subjected to body contouring surgery who died after gluteal lipoinjection. The main inclusion criterion was that the patient had a complete clinical history for the parameters sought; therefore, the main search was for cases of legal medicine that had criminal investigations and court trials for death secondary to gluteal lipoinjection. The parameters investigated were as follows: year of the event, age, sex, weight, height, body mass index, pathologic history of importance, operations combined with liposculpture, amount of liquids infiltrated in subcutaneous tissue, volumes of liposuction and lipoinjection, beginning of the problem, symptomatology and evolution of the disease, and findings at autopsy, specifically the presence of microscopic or macroscopic fat embolism. The cases studied were concentrated for a general analysis, and to perform comparative analysis, the cases were grouped according to specific findings of importance. The results were subjected to statistical analysis for nonparametric variables, performing analyses between groups with the Mann-Whitney *U* test and IBM SPSS (IBM Corp., Armonk, N.Y.).

RESULTS

In total, 16 autopsy files were found that met the full file requirements; 12 of them were in Bogotá, two were in Cali, and two were in Medellin. The Bogotá cases were taken from the Institute of Legal Medicine, and the other four were cases of criminal investigations that required necropsy. All patients were women aged between 23 and 53 years (mean, 38.2 years), with weight between 51 and 68 kg (mean, 60.1 kg) and height between 1.53 and 1.67 m (mean, 1.59 m). Body mass indexes ranged between 20.1 and 27.7 kg/m^2 (mean, 23.6 kg/m^2). No patient was obese, and only four (25 percent) were overweight, with body mass indexes between 25.6 and 27.7 kg/m^2 (mean, 26.5 kg/m^2). Fourteen patients were American Society of Anesthesiologists class I, and only two were American Society of Anesthesiologists class II, with diabetes and controlled hypertension in one patient and controlled hypertension in the other. The volume of subcutaneous infiltration was 2000 to 6500 cc (mean, 4037 cc), and the total volume of liposuction was 800 to 6500 cc (mean, 3117 cc). The amount of fat lipoinjected per gluteus was 120 to 350 cc (mean, 214.37 cc). Twelve operations (75 percent) were exclusively liposuction with gluteal lipoinjection, although eight operations (50 percent) were scheduled for more procedures, which were not performed because of the complications that arose during surgery. The four additional operations performed were two abdominoplasties and two rhinoplasties. The average time of surgery, counted from the beginning until the end or until suspension because of complication or death, was between 45 minutes and 4 hours 30 minutes (average, 2 hours 45 minutes)

The characteristic clinical picture of the 16 patients was bradycardia with severe hypotension and hypoxemia. Five patients (31.2 percent) started the problem at the time of gluteal lipoinjection, suffered cardiorespiratory arrest, and died immediately. Seven (43.7 percent) presented the clinical picture while still in surgery, after gluteal lipoinjection, and the surgery had to be stopped. Four (25 percent) were discharged without surgery problems and developed the clinical picture in the recovery area (mean, 2 hours). These 11 patients were transferred to the intensive care unit and died an average of 4 hours after having been admitted to the intensive care unit (two at 13 hours), 6.8 hours after the start of surgery (1.5 to 16 hours)

The forensic diagnosis of death in all cases was fat embolism, and during the autopsy, all had microscopic fat embolism in the lung; 10 (62.5 percent) also had macroscopic fat embolism in the lung, pulmonary vessels, and cardiac vessels. Three of these 10 patients who had macroscopic fat embolism in the lung also had fat in other organs: two in the brain and one in the kidney. Only one of the six patients who did not have macroscopic fat in the lung had fat in the kidney. The overall results are shown in Tables 1 through 3.

A comparative analysis was performed between the patients who had macroscopic fat embolism and those who had only microscopic fat embolism in the lung. The mean ages of the patients were 42 and 32 years for macroscopic and microscopic fat embolism in the lung, respectively, with average body mass indexes of 23.8 kg/m^2 for macroscopic fat embolism and 23.2 kg/m^2 for microscopic fat embolism in the lung. The total liposuctioned amount was 2360 and 4378 cc for macroscopic and microscopic fat embolism in the lung, and the amount lipoinjected was 187 and 260 cc for macroscopic and microscopic fat embolism in the lung, respectively. Of the 10 patients who suffered macroscopic fat embolism, five experienced symptom onset at the time of lipoinjection and died immediately, four experienced symptom onset during surgery, and one experienced symptom onset immediately after the procedure and later died in the intensive care unit. Of the six who suffered only microscopic fat embolism in the lung, one experienced symptom onset at the time of

Table 1. General Data Obtained from Patient Records

Patient	Sex	Age (yr)	Weight (kg)	Height (cm)	BMI (kg/m^2)	Chronic Diseases	Volume of Subcutaneous Infiltration (cc)	Volume of Liposuction (cc)	Volume of Lipoinjection per Gluteus (cc)	Addition Surgery Scheduled
1	F	23	59	160	23.05	No	4050	3500	250	Abdominoplasty
2	F	43	60	158	24.03	No	4050	3275	210	Abdominoplasty
3	F	37	51	159	20.17	No	4000	2600	120	Septoplasty*
4	F	27	55	160	21.48	No	6000	6000	300	No
5	F	42	55	154	23.19	No	6000	2300	150	Blepharoplasty plus abdominoplasty†
6	F	37	60	160	23.44	No	2000	800	230	Breast pexia†
7	F	51	63	154	26.56	Diabetes, HBP	3000	2000	200	Breast augmentation plus abdominoplasty†
8	F	28	68	161	26.23	No	4000	4000	250	Rhinoplasty
9	F	52	65	153	27.77	No	3500	3500	220	No
10	F	39	53	155	22.06	No	4000	2600	120	Rhinoplasty
11	F	28	60	167	21.51	No	6500	6500	350	No
12	F	38	57	158	22.83	No	6000	3000	150	Abdominoplasty†
13	F	43	65	168	23.03	No	3500	3000	200	Breast reduction†
14	F	44	57	158	22.83	No	2000	800	230	Breast reduction†
15	F	53	64	158	25.64	HBP	2000	2000	200	Breast augmentation†
16	F	27	60	157	24.34	No	4000	4000	250	No
Mean		38.25	59.5	159			4037.5	3117.19	214.38	

BMI, body mass index; HBP, high blood pressure.
*Time the surgery was terminated or suspended because of an adverse event.
†Scheduled surgery not performed because of an adverse event.

Table 2. General Data Obtained from Patient Records

Patient	Surgical Time*	Time of Symptom Onset	Intraoperative Heart Failure	Intraoperative Death	Time of Death after Entering ICU (hr)	Time of Death from Start of Surgery (hr)
1	4	3 hr after surgery	No	No	7	14
2	4.5	1.5 hr after surgery	No	No	3	9
3	4	At the time of lipoinjection	Yes	Yes	During surgery	4
4	2.15	A few minutes before the end of surgery	No	No	3	5.5
5	0.75	At the time of lipoinjection	Yes	Yes	During surgery	0.75
6	1	At the time of lipoinjection	No	No	3	4
7	2	At the time of lipoinjection	No	No	2	4.5
8	2.75	3.3 hr after surgery	No	No	4	10
9	3	At the time of lipoinjection	Yes	Yes	During surgery	3
10	2.5	At the time of lipoinjection	Yes	Yes	During surgery	2.5
11	3.5	A few minutes before the end of surgery	No	No	2	5.5
12	1.5	At the time of lipoinjection	Yes	Yes	During surgery	1.5
13	2.5	At the time of lipoinjection	No	No	13	16
14	1	At the time of lipoinjection	No	No	3	4
15	2	At the time of lipoinjection	No	No	2.5	4.5
16	3	0.5 hr after surgery	No	No	2	5.5
Mean	2.44				4.05	6.88

*Time the surgery was terminated or suspended because of an adverse event.

lipoinjection, two during surgery after lipoinjection, and the remaining three in the recovery area, having already finished surgery. None died during surgery, but all died in the intensive care unit. The mean times spent in the intensive care unit before death were 2.5 and 5.3 hours for the macroscopic and microscopic fat embolism in the lung patients, respectively. All these data are summarized in Tables 4 through 6.

A comparative analysis was also performed between patients who died during surgery and those who died after surgery. Five patients died during surgery, and 11 died after surgery. The mean ages of patients who died during surgery and after surgery were 41.6 and 36.7 years, respectively and their mean body mass indexes were 23.20 and 23.91 kg/m^2, respectively. All patients who died during surgery were American Society of Anesthesiologists class I, whereas the two patients who died after surgery were American Society of Anesthesiologists class II. The volumes of liposuction and lipoinjection were 2800 and 3261 cc and 152 and 242 cc for those who died during surgery and after surgery,

Table 3. General Data Obtained from Patient Records

Patient	Macroscopic Fat‡	Microscopic Fat in the Lung	Fat in Other Organs
1	No	Yes	No
2	No	Yes	No
3	Yes	Yes	No
4	No	Yes	No
5	Yes	Yes	Yes, brain
6	Yes	Yes	No
7	Yes	Yes	Yes, kidney and brain
8	No	Yes	Yes, kidney
9	Yes	Yes	No
10	Yes	Yes	No
11	No	Yes	No
12	Yes	Yes	Yes, brain
13	No	Yes	No
14	Yes	Yes	No
15	Yes	Yes	No
16	Yes	Yes	No

‡Fat in large pulmonary and cardiac vessels.

respectively. The five patients who died during surgery had macroscopic fat in the lung; in those who died after surgery, five (45 percent) had macroscopic fat in the lung, and six (55 percent) did not. Two of the patients who died during surgery (40 percent) had fat in other organs, and three (60 percent) did not, whereas nine of the 11 patients (81 percent) who died after surgery had no fat in other organs, and only two (19 percent) did. These results are summarized in Tables 7 and 8.

DISCUSSION

Gluteal lipoinjection with liposuction has become among the most successful combinations performed by plastic surgeons to achieve body contouring.[8,9] In many places, more than 90 percent of plastic surgeons perform a combination of the two procedures as part of their surgical approach to improve the gluteal contour.[9,10] Unfortunately, gluteal lipoinjection has also become a high-risk procedure when it is not performed correctly, without considering the relevant recommendations.[7,11,12] Classic fatty embolism syndrome, known in other medical specialties such as traumatology,[13] emerged in conjunction with liposuction some decades ago.[14,15] However, macroscopic fat embolism secondary to gluteal lipoinjection is a recently identified abnormality,[7] which occurs when fat is introduced into the bloodstream as a

Table 4. Comparative Analysis between Patients in the Total Group and Patients with Macroscopic and Microscopic Fat Embolism in the Lung

	No. of Patients	Sex	Age (yr)	Weight (kg)	Height (cm)	BMI (kg/m^2)	Personal Medical History	Volume of Subcutaneous Infiltration (cc)	Volume of Liposuction (cc)
Total group	16	F	38.25	59.5	158	23.67	14 ASA I, 2 ASA II	4037.5	3117.18
MAFE	10	F	42	58.50	157	23.88	8 ASA I 2 ASA II	3650.00	2360.00
MIFE	6	F	32	61.17	162	23.26	6 ASA I	4683.33	4379.17

BMI, body mass index; ASA, American Society of Anesthesiologists; MAFE, macroscopic fat embolism; MIFE, microscopic fat embolism.

Table 5. Comparative Analysis between Patients in the Total Group and Patients with Macroscopic and Microscopic Fat Embolism in the Lung

	Volume of Lipoinjection per Gluteus (cc)	Combined Surgery (%)	Surgical Time (hr)*	Moment of Symptom Onset	Heart Failure during Surgery (%)	Intraoperative Death (%)
Total group	214.37		2.44	5 at the time of lipoinjection,		
Yes		12 patients (75)		7 after lipoinjection before	5 (31.25)	5 (31.25)
No		4 patients (25)		the end of surgery, 4 after completing surgery	11 (68.75)	11 (68.75)
MAFE	187.00	1 with additional surgery	2.07	5 at the time of lipoinjection,		
Yes				4 during surgery after	5 (50)	5 (50)
No				lipoinjection, 1 arriving to recovery room	5 (50)	5 (50)
MIFE	260.00	3 with additional surgery	3.23	3 after finishing the surgery,		
Yes				2 during surgery after		
No				lipoinjection, 1 during lipoinjection	6 (100)	6 (100)

MAFE, macroscopic fat embolism; MIFE, microscopic fat embolism.
*Time the surgery was terminated or suspended because of an adverse event.

Table 6. Comparative Analysis between Patients in the Total Group and Patients with Macroscopic and Microscopic Fat Embolism in the Lung

	Intraoperative Death (%)	Time of Death after Entering the ICU (hr)	Time of Death after Surgery (hr)*	Macroscopic Fat (%)†	Macroscopic Fat In the Lung (%)	Fat in Other Organs (%)
Total group		4.04	6.88		100	
Yes	5 (31.25)			10 (62.5)		4 (25)
No	11 (68.75)			6 (37.5)		12 (75)
MAFE		2.5	4.21		100	3 of 10 (30)
Yes	5 (50)			6 (100)		
No	5 (50)					
MIFE		5.3	10		100	1 of 6 (16.6)
Yes				0 (0)		
No	6 (100)					

MAFE, macroscopic fat embolism; MIFE, microscopic fat embolism.
*Time the surgery was terminated or suspended because of an adverse event.
†Fat in large pulmonary and cardiac vessels.

Table 7. Comparative Analysis between Patients in the Total Group and Patients with Intraoperative and Postoperative Death

	No. of Patients	Sex	Age (yr)	Weight (kg)	Height (cm)	BMI (kg/m^2)	Personal Medical History	Volume of Subcutaneous Infiltration (cc)	Volume of Liposuction (cc)
Total group	16	F	38.25	59.5	158	23.67	14 ASA I, 2 ASA II	4037.5	3117.18
Intraoperative death	5	F	41.60	56.20	156	23.20	5 ASA I, 0 ASA II	4700.00	2800.00
Postoperative death	11	F	36.73	61.00	160	23.91	9 ASA I, 2 ASA II	3736.36	3261.36

BMI, body mass index; ASA, American Society of Anesthesiologists.

Table 8. Comparative Analysis between Patients in the Total Group and Patients with Intraoperative and Postoperative Death

	Volume of Lipoinjection per Gluteus (cc)	Combined with Another Operation (%)	Macroscopic Fat*	Microscopic Fat in the Lung (%)	Fat in Other Organs
Total group	214.37			100	
Yes		4 (25)	10 (62.5).		4 (25)
No		12 (75)	6 (37.5)		12 (75)
Intraoperative death	152.00	1 of 5 (20)		100	
Yes			5 (100)		2 (40)
No					3 (60)
Postoperative death	242.73	3 of 11 (27.7)		100	
Yes			5(45)		2 (19)
No			6 (55)		9 (81)

* Fat in large pulmonary and cardiac vessels.

result of a lesion to the gluteal blood vessels when performing lipoinjection.[7,16] Therefore, a venous lesion in the gluteal vessels at the time of a lipoinjection can produce fat entering the bloodstream in a macroscopic form, or in a microscopic form (Figs. 1 and 2).

This is the first published study in which the clinical picture of fat embolism secondary to gluteal lipoinjection has been analyzed in a group of patients, correlating it with the characteristics found during the autopsy and at the histopathologic level. The data obtained in this study have helped us to understand more about the particularities secondary to the introduction of fat into the circulation, such as the manifestations and clinical behaviors of the conditions. To be able to collect reliable key data, patient files had to be identified in which the information was as accurate as possible and the data could exist to achieve the required objectives.

Factors such as age, body mass index, amount of liposuctioned fat, and even the amount of fat lipoinjected into the gluteus were not elements that constituted causes that influenced the appearance

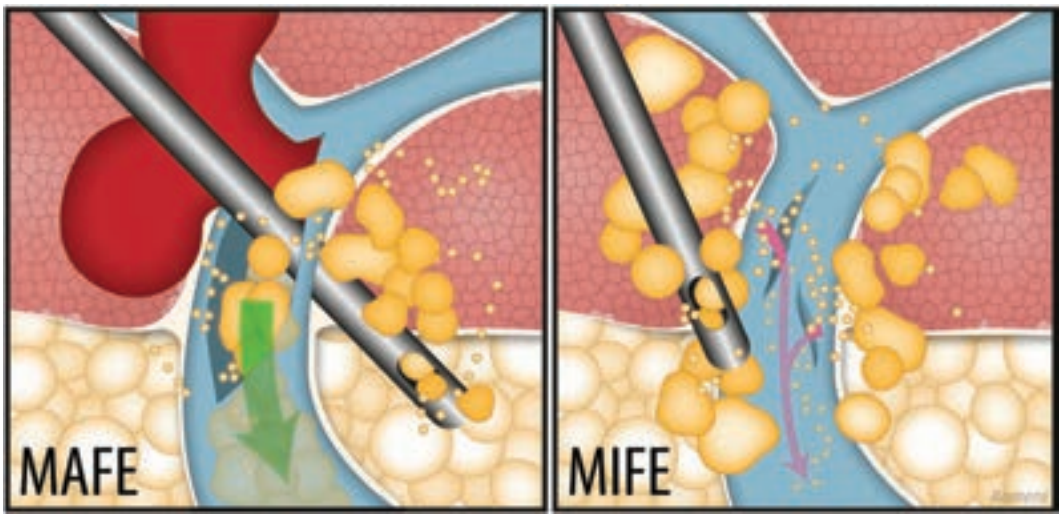

Fig. 1. The venous injury when injecting fat into the gluteus can occur in large or small vessels. Lesions in large vessels produce fat entry in macroscopic form (*MAFE*), whereas the multiple lesions of small vessels will produce the entry of fat microscopically (*MIFE*).

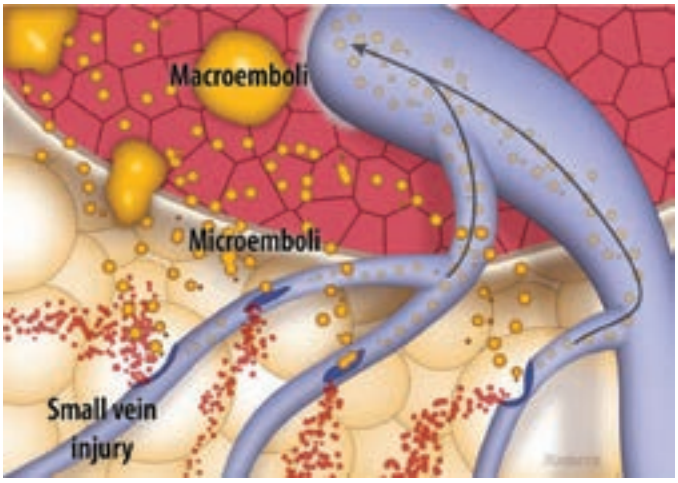

Fig. 2. Multiple lesions of small venous vessels are more likely to occur when injection is performed into highly vascularized areas, such as muscles.

of the clinical picture. This fact is essential because it could be thought that the problem could be intimately related to the volumes of fat suctioned or injected during surgery. None of these factors had significance, either when analyzed in isolation or when compared between groups of macroembolism versus microembolism or deaths during surgery versus deaths after surgery (Tables 4 through 8). The characteristic clinical picture consisting of the triad of acute bradycardia, hypoxemia, and hypotension is a constant that must be considered in all patients. Because of unexpected changes in heart rate, blood pressure, or oxygen saturation, hemodynamic support measures should be urgently implemented to attempt to address the problem satisfactorily.

A relevant finding is that, although all patients showed fat embolism as a cause of death, the presence of macroscopic fat substantially influenced the evolution and the characteristics of the clinical picture. As reported previously, lesions in gluteal vessels during lipoinjection allow fat to enter the bloodstream and produce cardiovascular collapse with immediate death[7] (Fig. 3), which was confirmed in the present study, where all patients who died immediately at the time of gluteal lipoinjection had macroscopic fat in their large pulmonary and cardiac vessels (Figs. 4 through 6). Common

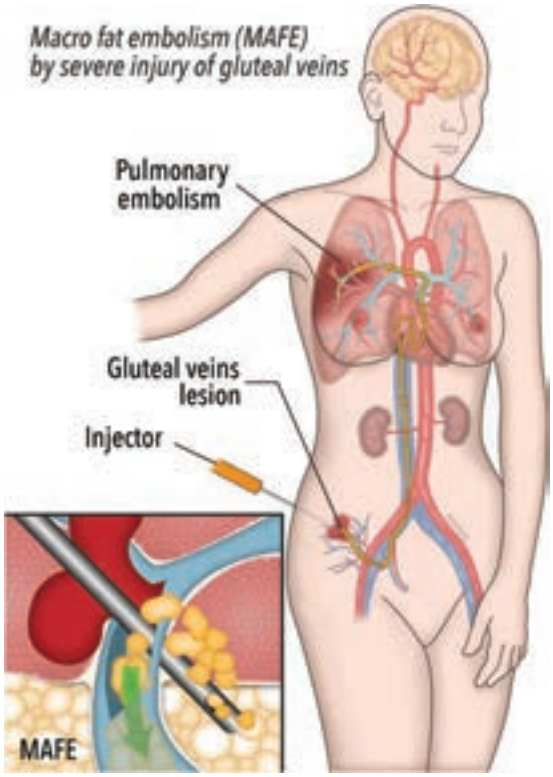

Fig. 3. The venous injury of large vessels in the gluteus favors the entry of fat in macroscopic form into the bloodstream (*MAFE*). This fat reaches the lung through the heart chambers, producing a pulmonary embolism.

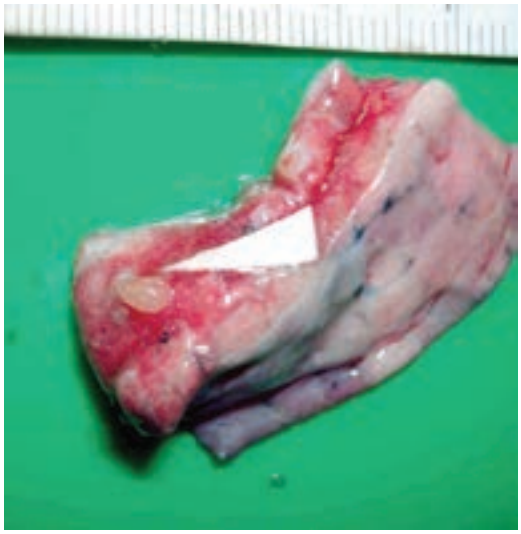

Fig. 4. Macroscopic fat in cardiac cavities in a patient with macroscopic fat embolism.

findings in the autopsies of both groups included the presence of fat in anatomical spaces where fat does not exist (Figs. 7 and 8). A very significant fact was that 10 of the 11 patients who had macroscopic fat in their pulmonary and cardiac

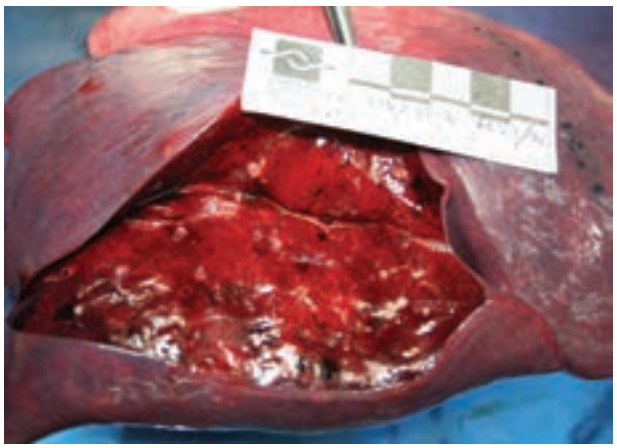

Fig. 5. Fat in lung of patient with macroscopic fat embolism.

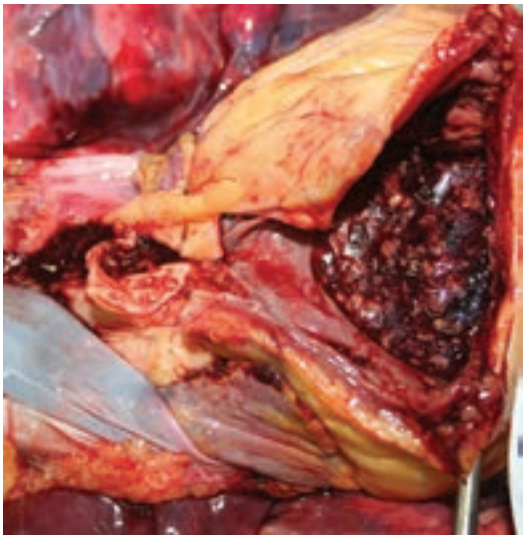

Fig. 6. Fat in the right ventricle caused by macroscopic fat embolism. (Image has appeared previously in Cárdenas-Camarena L, Bayter JE, Aguirre-Serrano H, Cuenca-Pardo J. Deaths caused by gluteal lipoinjection: What are we doing wrong? *Plast Reconstr Surg.* 2015;136:58–66.)

vessels began their clinical presentation during the surgical procedure, and the surgery had to be finished; the remaining patient started presenting complications immediately after surgery. Five of these 11 patients were those who died immediately after lipoinjection, and six died in the intensive care unit, with an average survival time in the intensive care unit of 2.5 hours, unlike those who presented only microscopic fat embolism, whose survival was 5.3 hours. Three of the six patients with microscopic fat embolism began their clinical pictures 1.5, 3, and 3.30 hours after surgery, indicating that macroscopic fat embolism produces a clinical picture of sudden onset and more severe behavior. The amount of fat in the circulation and

Fig. 7. Fat in the piriformis space adjacent to the pyramidal or piriformis muscle. Free fat is seen around the sciatic nerve and venous vessels.

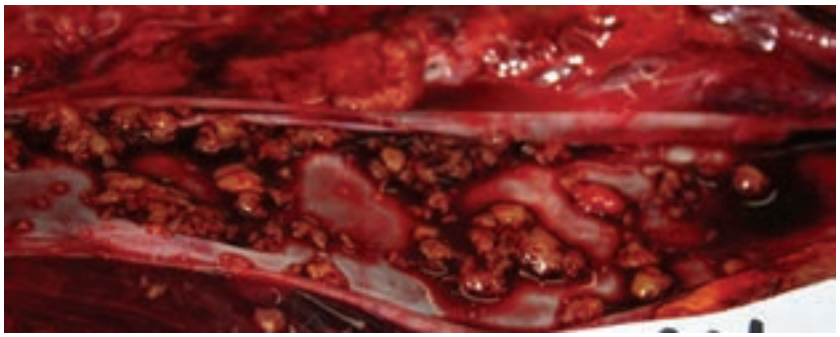

Fig. 8. Fat inside the vena cava in a patient who died as a result of macroscopic fat embolism. (Image has appeared previously in Cárdenas-Camarena L, Bayter JE, Aguirre-Serrano H, Cuenca-Pardo J. Deaths caused by gluteal lipoinjection: What are we doing wrong? *Plast Reconstr Surg.* 2015;136:58–66.)

especially the presence of macroscopic fat in the pulmonary and cardiac vessels carry a direct correlation with the speed and severity of the evolution and can make a difference in the probability of death (Fig. 7).

It is also essential to note that not all patients with macroscopic fat embolism died immediately; 50 percent of these patients did not present an immediate death as expected and died hours after surgery in the intensive care unit. This finding indicates that, despite the presence of a macroembolism, patients could survive for some hours with vigorous cardiopulmonary resuscitation. This information is crucial because it introduces the possibility that when facing a similar problem, proper management and vital support in an advanced unit could make the difference between life and death for some of these patients. The reason why some patients survived a few hours after the onset of the condition was not evaluable or possible to determine in this study because the patient analysis focused only on patients who died, but it is very possible that other cases presented similar pathologic conditions and survived because of appropriate treatment in the intensive care unit.

We must consider that the presence of macroscopic fat in large vessels led to greater involvement of distant organs. Of the four cases of emboli in kidney and brain, three corresponded to patients with macroembolism and only one to a patient with microembolism, the latter being the patient who presented their clinical picture the latest. The explanation for this last event could be that the fat spent more time in circulation and eventually affected distant organs, and because when there is fat entering the bloodstream in a macroscopic manner, there will also be fat in microscopic form (Fig. 8).

In this study, we found that the onset of clinical signs of fat embolus following gluteal lipoinjection may be immediate or may begin within

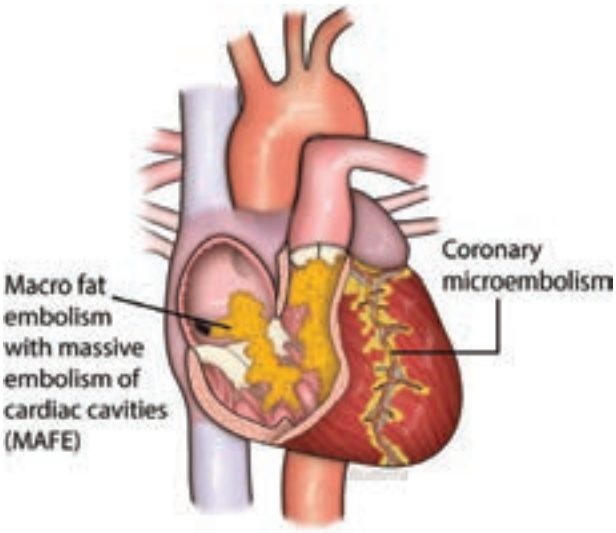

Fig. 9. The presence of macroscopic fat in cardiac cavities and adjacent vessels produces mechanical failure of the heart; this is an essential characteristic of the macroscopic fat embolism (*MAFE*).

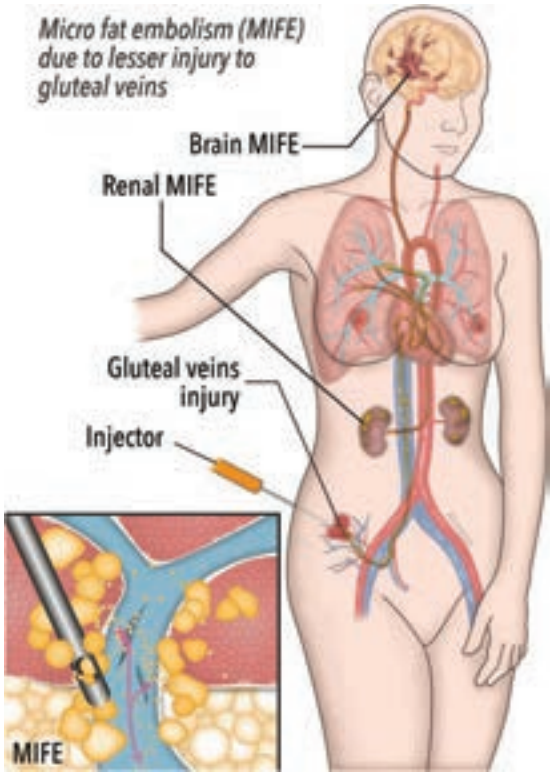

Fig. 10. When the lesion is multiple in small venous vessels, the fat enters the bloodstream in microscopic form (*MIFE*). This fat reaches the heart, subsequently affecting the pulmonary capillaries and remote organs such as the brain, liver, or kidney.

a few hours after surgery. The most severe and aggressive cases are directly related to macroscopic fat embolism, whereas when it starts after surgery, it is usually associated with microscopic fat embolism. However, when microembolism is severe, it can have mechanical cardiac effects like those of macroembolism and can be as serious as a macroembolism, even leading to death. In this case series, sudden death or death during the first hours occurred because both macroembolisms and microembolisms behave with eminently mechanical effects, which favor the complications of heart failure and death, as evidenced by the triad of hypoxemia, hypotension, and bradycardia. Emboli deposited in large vessels and pulmonary vessels fully explain this evolution. Hypotension and bradycardia are secondary to obstruction of cardiac vessels and cardiac cavities, and hypoxemia is caused by obstruction of pulmonary vessels (Fig. 9). We must consider that this problem, when it arises during surgery or immediately after surgery, is completely different from the classic fat embolism syndrome described by Gurd and Wilson,[17] which is characterized by involvement of the pulmonary, cutaneous, and cerebral microcirculation (Fig. 10). In patients with classic fat embolism syndrome, the biochemistry, theory, secondary to the effects of serum lipase on fat particles and the release of highly irritating fatty acids, is what causes damage to the previously mentioned microcirculation. In this study, the involvement of the microcirculation was eminently mechanical at the pulmonary level; this involvement is understandable because the fat that enters the bloodstream is lodged primarily and immediately in the pulmonary microcirculation after passing through the heart (Fig. 11).

Although the differentiation between macroscopic and microscopic fat embolism is important, it should be noted that, as we have seen in this article, there are patients who, without evidence of macroscopic thrombus, behave as if a macroembolism is present. The explanation for this situation may that these patients initially appear as having macroscopic fat embolism, with mechanical lung disorders, but secondary to cardiopulmonary resuscitation, these macrothrombi spread to the whole lung, creating a massive microscopic fat embolism that is fatal. This characteristic is why we must consider that the two entities overlap and that what matters most is the amount of fat that gets into the bloodstream and reaches the lung.

Unfortunately, this is a retrospective study in which the data were obtained from files of patients that died of gluteal lipoinjection, and many important data were not reported in those files. Primordial information to obtain in future cases

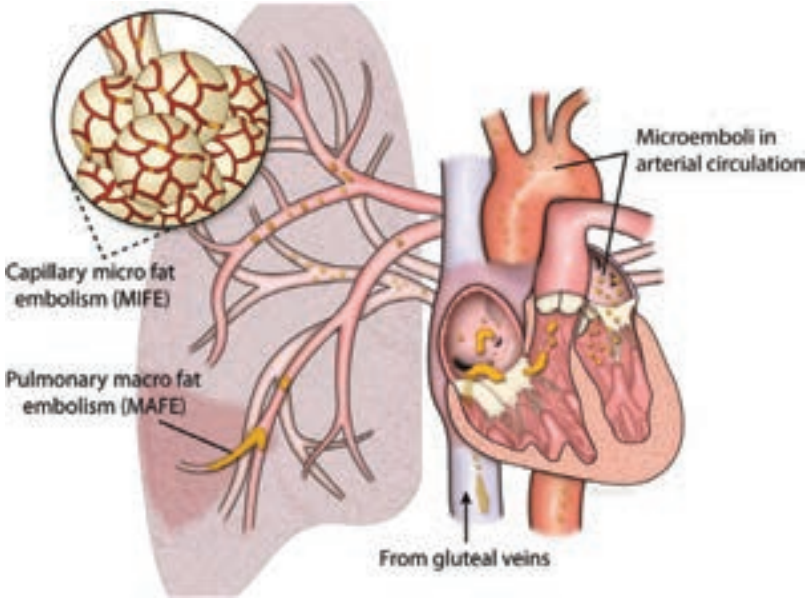

Fig. 11. The conformation of major fatty emboli produces macroscopic fat embolism (*MAFE*) that can cause obstruction of large pulmonary vessels. However, small microemboli can obstruct pulmonary capillaries and some others can pass into the arterial circulation (*MIFE*).

of microscopic and macroscopic fat embolism is to look for lesions of the gluteal vessels and investigate the exact plane where fat was infiltrated. These data will help us to better understand the problem and dispel many doubts.

CONCLUSIONS

With this work, we have shown the characteristic clinical picture of a fatal fat embolism secondary to a gluteal lipoinjection. The most significant parameter of severity in patients who undergo gluteal lipoinjection is the presence of macroscopic fat in the bloodstream, without influence from the volumes of liposuctioned or lipoinjected fat. The sudden onset of the triad consisting of hypoxemia, hypotension, and bradycardia should be an alarm to act immediately, and although there is no specific treatment for the problem, aggressive vital support should be instituted immediately to attempt to avoid death and to stabilize the patient. It is possible that, in overcoming the acute state of the problem, the patient has a greater chance to survive. However, knowing the results of this work and other recent works, we can outline the following recommendations to reduce the risk of presenting macroscopic and microscopic fat embolism:

1. It is advisable not to lipoinject the upper fraction obtained during liposuction because it contains the greatest amount of free fatty acids, and this could be a factor that favors the appearance of microscopic fat embolism.
2. Adequate hydration of any patient undergoing liposuction is essential; this facilitates elimination of fatty acids from the blood.
3. Lipoinjection must be reduced in highly vascularized areas, such as muscles. This decreases the risk of introducing large amounts of fat into the bloodstream.
4. To prevent injuring the gluteal vessels, deep intramuscular injections in the gluteal region, especially in the medial portion adjacent to the piriformis muscle, should be avoided.
5. In case of a sudden deterioration of the general state of the patient, the surgical procedure should be suspended, and the possibility of having fat in the bloodstream should be considered.
6. The use of methylprednisolone or ciclesonide before surgery should be considered as a preventive measure.

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