Setting up a plastination laboratory at the Faculty of Medicine of the Autonomous University of Barcelona

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SUMMARY

Plastination is a laboratory tool used to preserve biological tissues that has been applied to morphological studies, teaching and research. The technique reduces exposure to toxic fumes and diminishes damage to anatomical preparations during their manipulation.

Contrary to intuition, the basic technique of plastination does not require any significant economical investment. The technical equipment and laboratory products can be obtained with a limited budget. Moreover, facility requirements are simple and not very expensive if only the basic technique is pursued.

In the present work, we report our experience in the design and setting up of a laboratory to plastinate anatomical preparations using the S10 standard technique at the Faculty of Medicine of the Autonomous University of Barcelona. We explain the different ways we used to finance this laboratory and the cost of the facility, the technical equipment and the laboratory products. We also report the first results concerning the first anatomical preparations obtained by us.

Key words: Human anatomy – Plastination – Teaching anatomy – Plastination laboratory – S10 technique

INTRODUCTION

Since Prof. Gunther von Hagens developed the plastination technique at the end of the seventies as a new method to preserve anatomical preparations (Von Hagens, 1979; Bickley et al., 1981; Von Hagens et al., 1987) many Investigation Centres and Schools of Medicine have incorporated this technique to improve research and teaching in the Departments of Anatomy. The main advantages are that plastinated specimens are dry, odourless and durable. Moreover, they even retain structural details down to histological level, which increases their value not only for the teaching of anatomy, but also in some cases for basic investigation (Tiedemann and Von Hagens, 1982; Cook, 1997; Schiltenwolf et al., 1997; Sittel et al., 1997; Weiglein, 1997). Furthermore, this method of tissue preservation considerably reduces the exposure of students, professors and technical assistants to carcinogenic toxic fumes. However, the design of a plastination laboratory frequently involves technical issues, structural problems of the facility and, especially economic problems that may delay its opening and the possibility of obtaining plastinated anatomical specimens in a brief period of time.

Anatomy teaching at the Faculty of Medicine of the Autonomous University of Barcelona (UAB) is divided into three core subjects along the two first courses of studies in Medicine. The total number of students is around 600. Anatomical practical work of students in the dissecting room represents a total of 56 hours/student distributed along 24 practice sessions. Since medical students are very interested in anatomy and practice sessions, they frequently ask about the possibility of completing the study of anatomical preparations outside the programmed sessions. However, some issues hinder this possibility: the

Submitted: December 4, 2003
Accepted: February 26, 2004

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availability of tutors and technical staff; the need of a laboratory where they can study without interfering with the programmed activity in the dissecting room; damage to preparations, and over-exposure to toxic fumes.

The present work reports the experience of the Faculty of Medicine at the UAB in the design and setting up of a plastination laboratory that has been located adjacent to the dissecting room. The main objectives of this experience were: A. To initiate plastination by the easiest and cheapest plastination technique (Biodur® S10 standard technique) making the financial and structural resources of the Faculty profitable. B. To initiate the elaboration of an anatomical collection of plastinated specimens in order to promote self-learning techniques in human anatomy. C. To reduce exposure to carcinogenic toxic fumes.

Material and methods

The plastination laboratory was designed in accordance with the International Society of Plastination (ISP) guidelines (ISP, 1998), the Collection of Technical Leaflets for Plastination from Heidelberg (Von Hagens, 1986), and the technical support and collaboration of the Plastination Laboratory of the University of Murcia (Spain).

The financial resources came from either the Faculty of Medicine and the Anatomy and Embryology Unit, or from economic resources obtained through external grants for increasing safety in research laboratories and promoting new techniques in teaching innovation (Table 1). The total capital investment in the plastination laboratory was of 9.749,52 €, (21,85 % for the facility, 61,75 % for technical equipment –Table 2– and 16,40 % corresponding to laboratory material –Table 3–).

Table 1.– Total financial resources for plastination laboratory start

FINANCIAL RESOURCES ALLOCATED TO THE PLASTINATION LABORATORY	
OWN RESOURCES	
- Department on Morpholocical Sciences (Faculty of Medicine)	3893.98 €
INTERNAL GRANTS	
- Announcement for "Improving of the personal security in research laboratories", 2001 (UAB)	
• Isolation of the plastination laboratory	1.081 €
• Acetone vapour extraction	600 €
• Technical modifications of freezers	1.844 €
EXTERNAL GRANTS	
- Announcement for "Grants to improve quality in teaching, 2001 (Generalitat de Catalunya)	3.000 €
TOTAL RESOURCES	**10.418,98 €**

The design of the plastination laboratory was carried out in order to start up the S10 standard technique from Biodur®. This is the method usually recommended to initiate plastination because it requires neither large financial investments nor specific technical support (Von Hagens, 1986; Gubbins, 1990; Weiglein, 1997). Briefly, the S10 technique consists of four basic steps (Von Hagens, 1986):

– Fixation: we used the fixation method by intravascular injection of the Cambridge solution (O'Sullivan and Mitchell, 1993).

– Dehydration: the freeze-substitution method was used. This consists of placing the anatomical specimens, previously fixed, into a series of dehydration baths with ascending concentrations of acetone at -25ºC. Stepwise dehydration and freeze substitution is completed when the water content is below 1%.

– Forced impregnation: This is the central step in plastination. The dehydrated specimen, soaked in acetone as a volatile intermedium (high vapour pressure and low boiling point) is placed into the polymer solution used for impregnation (S10/S3 100:1) at -25ºC under vacuum. These conditions make it easy to remove the acetone and the pressure difference cau-

Table 2.– Facility and equipment costs

BUILDING AND EQUIPMENT COSTS	
BUILDING	
Isolation of the plastination laboratory	770,23 €
Vapour extraction system	1.360,23 €
TECHNICAL EQUIPMENT	
Dehydration freezery	without cost
Freezer for impregnation	810,17 €
Technical modifications of freezers	2.342,23 €
Plasination kettle for impregnation (351)	812,96 €
Glass plate sealer for plastination kettle	39,88 €
Stainless steel basket for impregnation	104,81 €
Vacuum pump	1.183 €
Vacuum controllers and adjustment valves	290,88 €
Acetonometer 1-100%	39,88 €
Fine acetonometer 90-100%	54,20 €
Gas curing unit	without cost
Plastic buckets and other plastic material for laboratory	341,94 €
TOTAL	**8.151,54 €**

Table 3.– Polymers and chemical costs for the S10 technique

POLYMERS AND CHEMICAL COSTS	
Silicone rubber Biodur S10	1.023,87 €
Silicone hardener Biodur S3	28,12 €
Biodur Gas-Cure S6	92,03 €
Acetone (200 l)	212,50 €
Oil for vacuum pump (25 l)	241,46 €
TOTAL	**1.597,98 €**

ses the polymer solution to impregnate the specimen. The speed of the impregnation process is controlled by the level of the vacuum, which is adjusted by fine valves of an air entry port into the impregnation chamber. The process must be carried out slowly, just to reach a pressure of 5 mmHg maintained during three days. Bubble formation on the surface of the impregnation bath allows the process to be controlled.

– Curing: after the forced impregnation, resin polymerization is carried out at room temperature. The process is improved by the S6 gas-cure in the curing chamber.

The equipment acquired for the plastination laboratory was that essential for the S10 technique (Lischka and Prihoda, 1987; Gubbins, 1990): a freezer for dehydration and another for impregnation (although the latter is optional); a vacuum system to remove the acetone and allow the resin to enter the specimen; an impregnation chamber with a safety glass cover, and a chamber for curing (Table 2).

The technical design included basic safety measures to prevent hazards due to possible explosions (Table 2):

a) The technique works by cooling the acetone in the freezer to -25ºC, which reduces the potential hazard.

b) Isolation of the laboratory from the rest of the working area.

c) Impulsion air system and forced acetone vapour extraction.

d) Technical modifications to the freezers: the compressors were installed outside the laboratory and located 70 cm from the fume-hood. The thermostat was also relocated and all other electric lines were disconnected (e.g., warning lights).

e) The vacuum pump was located outside the laboratory due to its electric contacts and because the exhaust contains acetone vapour.

f) The vacuum control unit was also installed outside the laboratory.

g) The electric lines for freezers and vacuum pump were installed outside the laboratory.

Results

The financial resources (Table 1) allowed us to start up a plastination laboratory located within the technical area of the dissecting room. It has ISP technical and safety requirements and was designed by the architecture unit of the UAB. The laboratory occupies a total surface of 12,5 m^2 (Figure 1a, 1b). This surface is sufficient to hold two freezers (one for dehydration and another for forced impregnation), a working area with stands and a sink, and a curing chamber of 140 dm^3 made of methacrylate (Figure 1).

The laboratory is isolated from the rest of the technical area by a transparent partition that allows one to control the rest of the laboratory when inside it (Figure 1b, 1c). The laboratory has a forced extraction system provided with nozzles on both sides of the freezers and located under their door level due to acetone vapour being heavier than air. The freezer compressors, the vacuum pump and its controls, as well as the electric lines are installed outside the laboratory (Figure 1c, 1d).

The time since we started to design the laboratory and to seek financial resources until the completion of the facility was 18 months. The plastination technique was begun in the spring of 2003.

The technique we have developed is the S10 standard technique from Biodur®, and we have applied it to the plastination of different anatomical regions (Figure 2). The results regarding the plastinated specimens are optimum with regard to preservation, colour and resistance. The protocols for plastination used by us are in accordance with the Collection of Technical Leaflets for Plastination from Heidelberg (Von Hagens, 1986). Figure 3 shows the processing time (expressed in days) of the different type of specimens.

Discusion

In recent years, part of the dissecting room of the Faculty of Medicine at the UAB has been remodelled, basically to improve the teaching in practical anatomy and to reduce the exposure to toxic fumes of teachers and technical staff as well as the students. Thus, the main interventions have been to reduce the formalin concentration in the fixative solution down to 3% (O'Sullivan and Mitchell, 1993; Sociedad Anatómica Española SAE, 1996), the preservation of specimens in a refrigerated chamber at 6ºC, which reduces vapours, the building of a new laboratory (technical area) provided with an impulsion and forced extraction air system below breathing

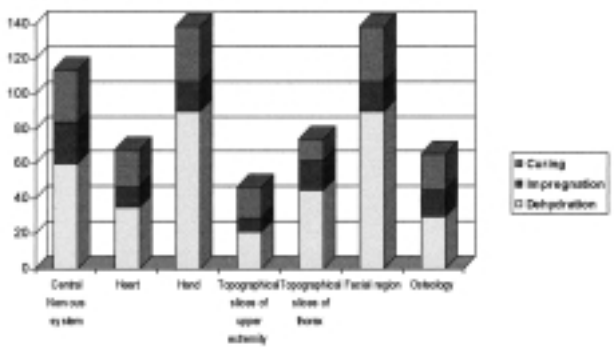

Fig. 3. Histogram of plastination processing time (expressed in days) corresponding to different anatomical regions in human.

level, and removal of the main tanks for immersed fixation with formalin.

Additionally, the new curricula in Medicine increase practical activities and their relevance in students' final evaluations. In this context, the presence of students in the dissecting room during the two first courses of Medicine at the UAB is 56 hours/student, and students frequently ask about the possibility of reviewing anatomic specimens outside programmed activities to better prepare for their exams or to improve their own knowledge. However, certain issues hinder this, such as the availability of teachers and staff, the need to be present in the dissecting room to work without interfering with programmed activities, damage to specimens, hazardous exposure to toxic fumes, etc. Currently, the development of new technologies in learning and the incorporation of teaching material in an intranet network and on the internet have partially solved these problems.

In this context, two years ago the Anatomy and Embryology Unit of the Faculty of Medicine at the UAB began the design of a new laboratory aimed at the plastination of anatomical specimens. The main objectives of this experience were on the one hand the development of a plastination laboratory, increasingly present in

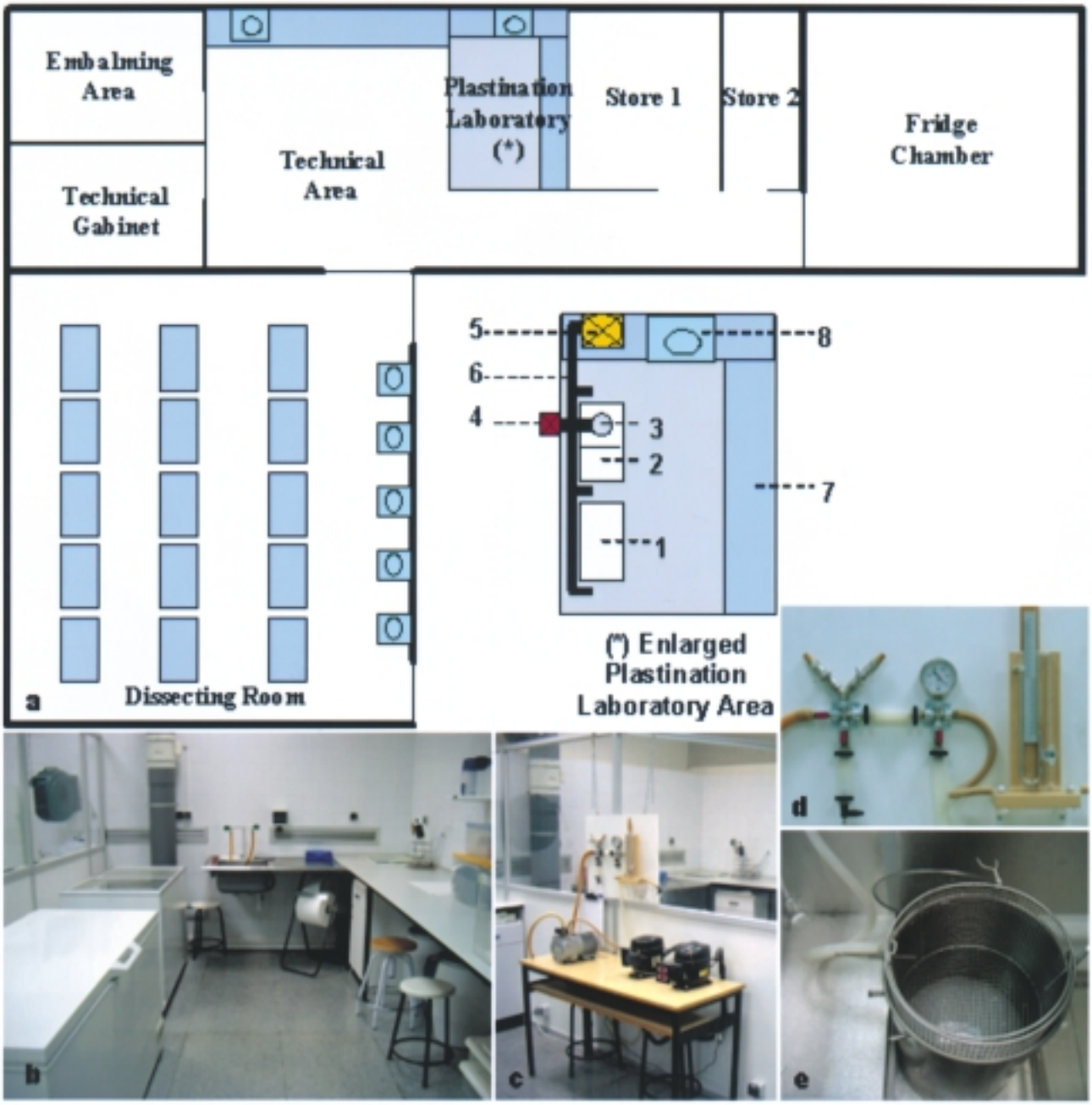

Fig. 1. Image showing a diagram of the dissecting room area and the plastination laboratory (**a**), distribution of technical equipment in the laboratory area (**b**), situation of vacuum pump and freeze compressors outside the laboratory (**c**), and details of the vacuum controls (**d**) and the plastination kettle (**e**). 1. Dehydration freezer (observed in 1b); 2. Forced impregnation freezer (observed in 1b); 3. Plastination kettle (shown in 1e); 4. Situation of vacuum pump, freeze compressors and vacuum controls (observed in 1c and 1d). 5. Forced extraction vacuum system (observed in 1b); 6. Tubes for forced air extraction in the laboratory area; 7. Working stand; 8. Sink.

the Faculties of Medicine, to improve the preservation of teaching preparations and to render access to such material by students easy, in order to promote techniques in self-learning, and, on the other hand, to reduce the exposure of teachers and students to carcinogenic toxic fumes during practical activities.

The plastination laboratory of the Faculty of Medicine at the UAB has been in use for less than a year, and for the most part its functioning has been entirely satisfactory. The technique we use is the S10 standard technique from Biodur®; this is because it is a very standardized technique; it is not difficult from a technical point of view, it requires minimum technical equipment and, finally, it offers a great range of possibilities (Von Hagens, 1986; Von Hagens et al., 1987; Gubbins, 1990).

Since acetone is used, the design of a plastination laboratory needs to take into account safety measures aimed at reducing fire/explosion hazards. In this sense, the laboratory needs to be

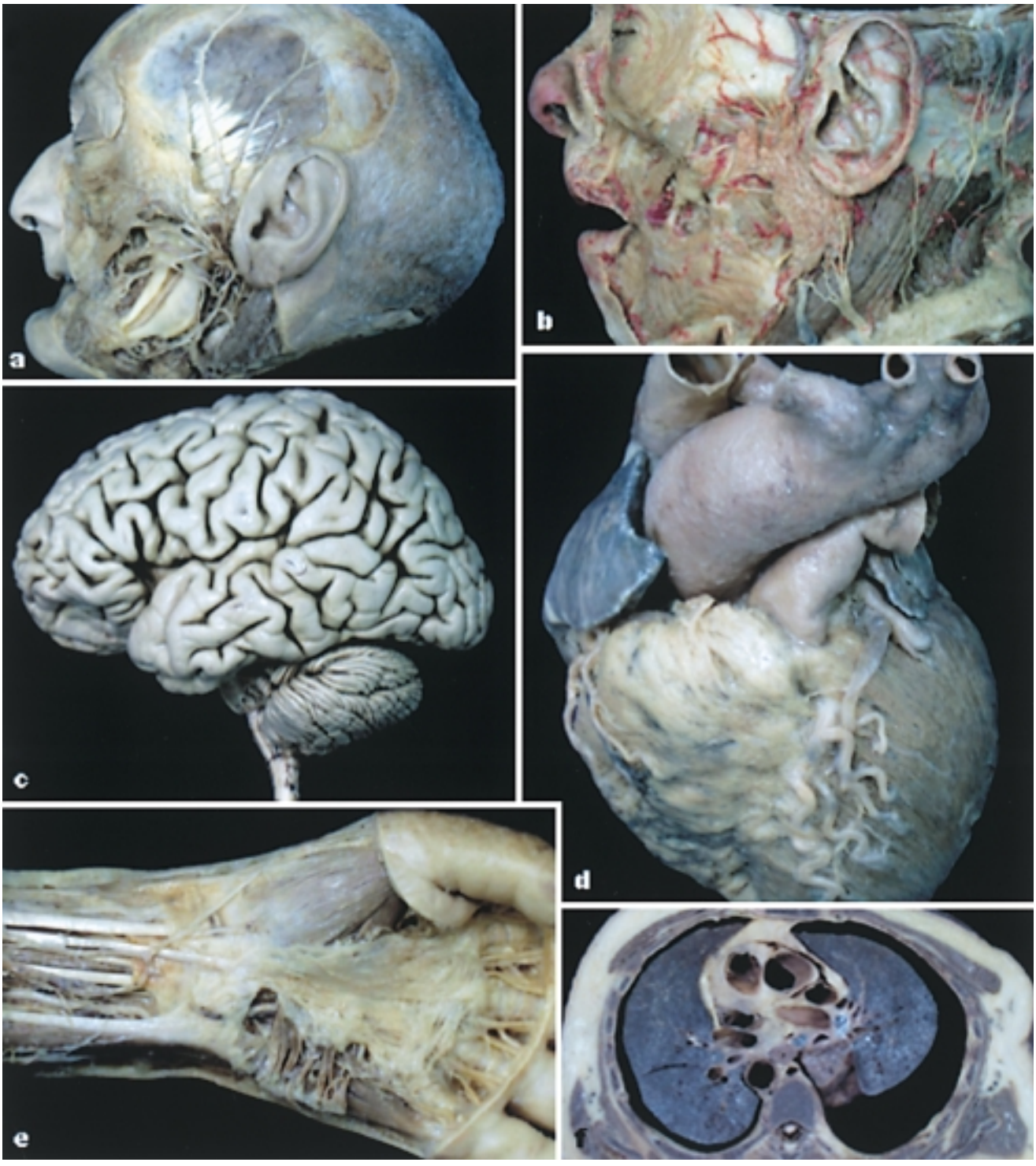

Fig. 2. Image showing different plastinated anatomical preparations corresponding to the facial region (**a, b**), the brain (**c**), the heart and its large vessels (**d**), the anterior region of the wrist and hand (**e**) and a topographical horizontal section of the thorax (**f**).

isolated from neighbouring facilities and it must be provided with a forced extraction air system and aspiration around the freezers and, if possible, around the curing chamber. This aspect, together with the reduction of formalin fumes, make it easy to access grants related to personal labour safety (Gubbins, 1990).

The plastination technique affords Anatomy Departments the possibility of setting up an anatomical collection that does not require any kind of preservation method. Moreover, these plastinated specimens may be at the students' disposal, thus promoting self-learning techniques in teaching (Masuda et al., 1997; Latorre et al., 1998; Orenes et al., 1999; Steinke, 2001). Financial resources related to improving learning and to the development of new learning methodologies can be applied for. Furthermore, in the near future the plastination technique should facilitate the development of new objective-based learning programs, with the incorporation of guided activities that do not require the presence of the students in the classroom (Boletin Oficial del Estado BOE, 2003).

In the future, as we increase the number of plastination specimens, it will be appropriate to assess the influence of this technique in the academic achievement of students. We believe that plastinated specimens will not replace the classical anatomic preparations, which have some advantages, such as their better approach to reality, their greater flexibility that makes their analysis by planes easier, and their relevance as a method for basic anatomical investigation. However, we do think that plastination undoubtedly facilitates the contact of students with Anatomy, and hence this technique must have positive repercussions on medical education, as recent studies have shown (Latorre, 2003).

Aknowledgements

This work has been supported by the Generalitat de Catalunya (Ajuts per la financiació de projectes per la Millora de la Qualitat Docent, 2001 -common project with the Faculty of Veterinary Science-), the Autonomous University of Barcelona (Ajuts per la Millora de la Seguretat en els Laboratoris d'Investigació, SEG2001-07) and the Department of Morphological Sciences (Faculty of Medicine) of the Autonomous University of Barcelona.

The authors thank Dr. R. Latorre for his assistance in the design and starting up the plastination laboratory. We also thank our technical staff (Mrs. Isabel Delgado and Mr. Manel Querol) for their helpful technical assistance.

References

Cook P (1997). Sheet plastination as a clinically based teaching aid at the University of Auckland. *Acta Anat*, 158: 33-36.

Bickley HC, Von Hagens G and Townsend FM (1981). An improved method for the preservation of teaching specimens. *Arch Pathol Lab Med*, 105: 674-676.

Boletín oficial del estado –BOE– (2003). Real Decreto 1125/2003. *BOE*, 224: 34355-34356.

Gubbins RBG (1990). Design of a plastination laboratory. *J Int Soc Plastination*, 4: 24-27.

ISP (1998). International Society for Plastination: plastination methods. *http:www.kfunigraz.ac.at/anawww/plast*.

Latorre R, Vázquez JM, Gil F, Ramírez G, López-Albors O, Arencibia A and Moreno F (1998). Macroscopic interpretation of horse head sectional anatomy using plastinated S-10 sections (abstr.). *J Int Soc Plastination*, 13: 39.

Latorre R, Vázquez JM, Gil F, Ramírez G, López-Albors O and Arencibia A (2003). Plastination techniques. A tool in Anatomy. *Eur J Anat,* 7 (suppl. 2): 37-38.

Lischka M and Prihoda M (1987). Establishing and operating a plastination laboratory at the Institute of Anatomy, University of Vienna. *J Int Soc Plastination*, 1: 12-16.

Masuda Y, Yoshida Y, Minagawa K, Zhang J and Yohro T (1997). Setting up and features of a database of images of plastinated materials. *Acta Anat*, 158: 10-20.

Orenes M, Latorre R, Vázquez JM, Gil F, Ramírez G, López-Albors O, Arencibia A and Moreno F (1999). Técnicas anatómicas aplicadas a la endoscopia del tracto gastrointestinal en el perro. *Imag Veter*, 2: 142.

O'sullivan E and Mitchell BS (1993). An improved composition for embalming fluid to preserve cadavers for anatomy teaching in the United Kingdom. *J Anat*, 182: 295-297.

Schiltenwolf M, Jakob DS and Graf J (1997). Sheet plastination of the vascularity of the lunate bone. A morphological study. *Acta Anat*, 158: 68-73.

Sittel C, Eckel HE, Ricke S and Stennert E (1997). Sheet plastination of the larynx for whole-organ histology. *Acta Anat*, 158: 74-80.

Sociedad Anatomica Española –SAE– (1996). Acta de Barcelona. Sobre Problemática de Salas de Disección y su Entorno. Tesitex SL, Salamanca, pp 38-61.

Steinke H (2001). Plastinated body slices for verification of magnetic resonance tomography images. *Ann Anat*, 183: 275-281.

Tiedemann K and Von Hagens G (1982). The technique of heart plastination. *Anat Rec*, 204: 295-299.

Von Hagens G (1979). Impregnation of soft biological specimens with thermosetting resins and elastomers. *Anat Rec*, 194: 247-255.

Von Hagens G (1986). Heidelberg Plastination Folder. Collection of Technical Leaflets for Plastination. Anatomisches Institut I, Universität Heidelberg, Heidelberg, pp 1.1-5.17.

Von Hagens G, Tiedemann K and Kriz W (1987). The current potential of plastination. *Anat Embryol*, 175: 411-421.

Weiglein AH (1997). Plastination in the neurosciences. *Acta Anat*, 158: 6-9.