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The Identification of Maternity in an Unusual Pregnancy-Related Homicide

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ABSTRACT: A recent bizarre homicide which culminated in the delivery of a live-born infant necessitated careful determination of true maternal origin. A 23-year-old pregnant woman was abducted, subdued, strangled, and delivered of a term infant by a crude Cesarean section. The infant was stolen and subsequently presented to physicians by a woman posing as the mother. Methods used to help confirm the surviving infant's parentage involved red cell antigen and enzyme system evaluations as well as immunoglobulin allotyping, which ultimately proved to be the most effective serologic test performed. The forensic science investigation of this unusual case also used bite mark analysis and patterned injury interpretation. Immunoglobulin allotyping is specifically discussed as a forensic serology test which is currently available and particularly applicable in cases involving parentage determination.

KEYWORDS: pathology and biology, maternity, genetic typing, immunoglobulins

Parentage determination is a problem typically encountered in clinical blood banks and serology laboratories, which usually examine samples from living subjects. Within the discipline of forensic pathology, however, undetermined parentage cases often involve deceased individuals. Such cases may be complicated by the lack of antemortem or postmortem blood samples suitable for the traditional blood group antigen and human leukocyte antigen (HLA) phenotyping used in parentage studies. Specifically, lymphocytes needed for HLA phenotyping are frequently nonviable in blood and tissue samples which remain uncollected or unprocessed for more than 12 h postmortem [*1*]. In spite of the limitations imposed by decomposition rates and specimen retrievability, red cell antigen and enzyme system evaluations can be and frequently are used for identification and characterization of deceased individuals, in the analysis of body fluid evidence obtained at crime scenes, and in forensic science cases requiring parentage determination [*2*].

The following case details the homicide of a pregnant woman which was coincidental with the crude Cesarean section delivery of her viable infant. The murderer subsequently claimed the infant as her own. The unusual circumstances of the crime presented the

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forensic pathologist with the dual challenges of obtaining and examining evidence sufficient to reasonably establish the sequence of events and of reliably establishing the infant's identity and parental origin. Resolution of the case required cooperation among multiple disciplines of forensic science including serology, odontology, patterned injury evaluation, and pathology.

Case Report

A 19-year-old woman clad in maternity clothes soiled by blood and dirt brought an infant girl to a hospital emergency room. She indicated that she had precipitously delivered the baby after having been involved in a minor motor-vehicle accident and requested that a physician examine her new baby. The woman then declined to be examined herself.

The partially blood- and vernix-covered newborn child was found to be healthy. Measurements indicated a gestational age of 38 weeks. The ragged umbilical cord stump was clamped and trimmed and the infant was admitted to the newborn nursery for observation. The putative mother was also admitted for observation. When she eventually submitted to a physical examination, several hours after admission, it was immediately apparent that she was not pregnant and had not recently been pregnant.

Meanwhile, local police had begun looking for a young pregnant woman who had disappeared from a local obstetrical clinic earlier that morning. Summoned to the hospital, police detectives questioned the hospitalized woman, who eventually admitted to abducting the missing woman and "taking" her child.

The following day she directed police to a remote canyon area, where the missing woman's body was found in an open field near a roadway and obscured from view by trees. The body was supine, with arms and legs extended and slightly flexed at the elbows and knees. The dead woman's blouse was pulled up to expose the mid abdomen, and a length of umbilical cord protruded from beneath blood-saturated maternity slacks, which covered the lower abdomen. Bruises and abrasions were about the face and neck, and the grass-covered ground on which the body lay was stained with dried, clotted blood. The decedent's open purse was on the ground to the left of her body, its contents scattered about. A key ring labeled with the decedent's name and holding seven metal keys lay in the grass near the right side of the body. One key was covered with adherent dried blood and tissue.

An autopsy was performed the following morning. There were numerous petechia of the face, eyelids, and conjunctiva. A horizontal linear red ligature abrasion extended across the anterior neck and onto the left lateral neck (Fig. 1). Several hemorrhages subjacent to the external ligature abrasions were within the anterior strap muscles and posterior esophageal wall, but the hyoid bone and thyroid cartilage were unbroken. The laryngeal mucosa was covered by petechial hemorrhages. Bite mark contusions and lacerations were on the anterolateral tongue surfaces. Separate small abrasions were along the suprasternal notch and on the back of the neck within the same horizontal plane as the ligature marks.

A 13- by 4-cm gaping horizontal incised wound, with focally abraded margins, was centered in the lower abdomen just above the symphysis pubis. Irregularly incised and torn abdominal musculature protruded from the defect along with a 33-cm length of umbilical cord. On the anterior-inferior uterine wall, which was visible through the abdominal defect, was a gaping 10-cm incised opening. Extending from the lateral edges of the abdominal incision were multiple-patterned injuries comprised of individual series of four parallel linear abrasions (Fig. 2). In the connective tissue between the urinary bladder and symphysis pubis were approximately 150 mL of clotted blood. A fully attached late third trimester placenta was within the uterus, but no fetus or fetal parts were identified. The eccentrically attached 54 cm length of umbilical cord had a torn, ragged

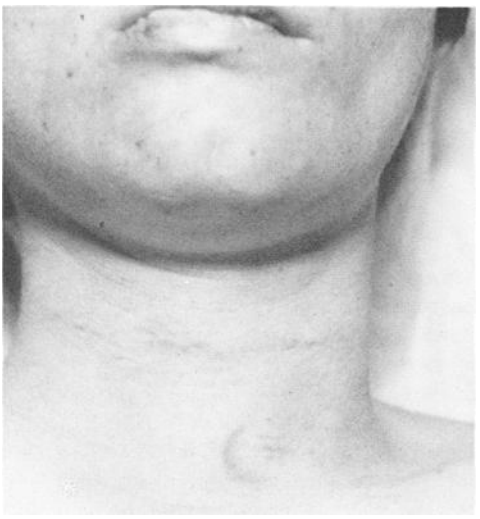

FIG. 1—*Faint ligature abrasions partially circumscribe the decedent's neck.*

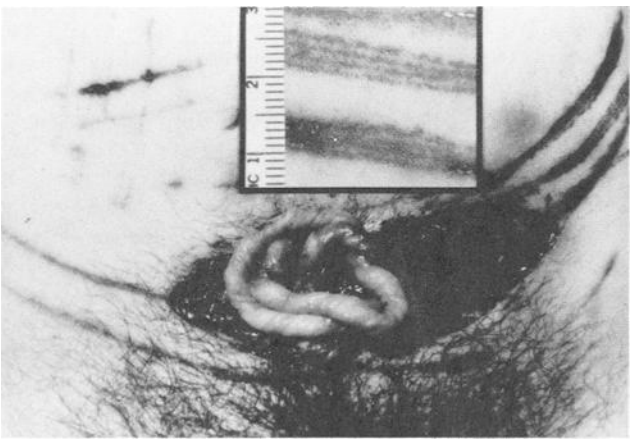

FIG. 2—*Numerous linear abdominal abrasions exhibit distinct patterning, most conspicuous along margins of gaping incision* (inset).

terminal end (Fig. 3), and on the distal portion of the cord were six individual rectangular to slit-like 0.4- to 0.8-cm puncture wounds.

The cause of death was determined to be ligature strangulation and exsanguination from an incised wound of the abdomen. The manner of death was homicide. The infant remained hospitalized, and the woman initially alledging to be the newborn baby's mother was arrested and charged with murder.

Physical Evidence

Blood specimens obtained at autopsy included nonpreserved and sodium-fluoride-preserved heart blood. Blood was also obtained from the hospitalized infant, the dece-

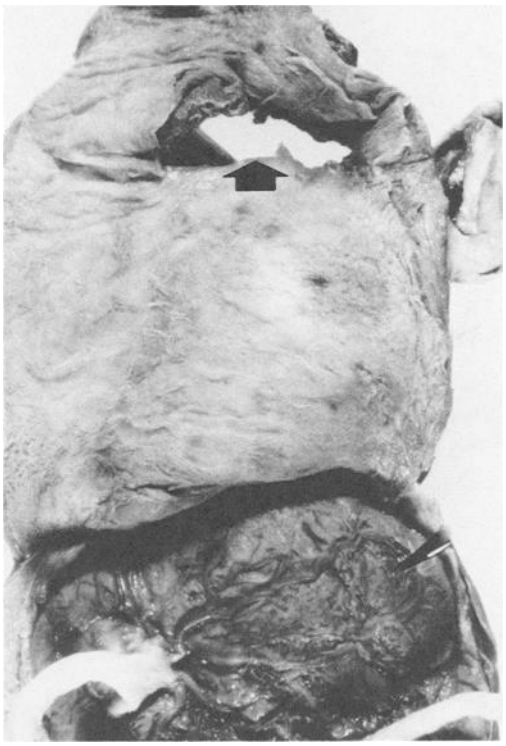

FIG. 3—*Internal surfaces of opened uterus show fully attached third trimester placenta. Gaping torn incision is within the anterior lower uterine segment* (arrow).

dent's husband, the suspect, and the suspect's husband. All subjects were Caucasians, with Anglo ethnicity. All nonpreserved blood specimens were subjected to a battery of serologic blood antigen and enzyme system assays. ABO antigens were determined using a standard absorption-elution hemagglutination technique. Group I enzyme systems including esterase D (EsD), phosphoglucomutase (PGM), and glyoxalase I (GLO I) were assayed by agar gel electrophoresis, and the remaining enzyme systems of erythrocyte acid phosphotase (ACP [EAP]), adenosine deaminase (ADA), and adenylate kinase (AK) were evaluated using starch gel electrophoresis [*3,4*]. Laboratory assay methods were based on standard techniques [*5*].

HLA phenotyping was performed on the blood specimen taken from the infant, but the extended postmortem interval eliminated the possibility of performing HLA phenotyping on the victim's blood or other tissues.

Results of the ABO red cell antigen and enzyme system studies are summarized in Table 1. These studies did not exclude the suspect and her husband as the parents and could not of themselves reliably establish the victim as the infant's mother.

Subsequently, immunoglobulin allotyping was performed on blood from the decedent, the infant, and the suspect using a passive hemagglutination inhibition method described by Schanfield et al. [*6,8*]. The results are summarized in Table 1. Immunoglobulin allotypes were identical for the infant and decedent. Random probability calculations, based on established GM and KM gene frequencies within the U.S. white population [*6*], identified the dead woman as the mother of this infant with greater than 85% probability. Additionally, the immunoglobulin allotypes categorically excluded the suspect as the infant's mother because immunoglobulin allotypes in the newborn infant and

TABLE 1—*Genetic marker investigations and calculations.*[a]

System	Husband	Decedent	L^b	Child	L^b	Suspect	Husband
ABO	A	A	1.08	A	1.08	A	0
ACP(EAP)	A, B	A, B	1.43	A	2.87	A	A
PGM	1, 2	1	NC[c]	1, 2	NC	1, 2	1
PGM(SUB)	1A, 2A	1A, 1B	1.57	1A, 2A	1.23	1A, 2A	1A
GLO	2	2	1.79	2	0.89	1, 2	1, 2
ESD	1	1	1.13	1	1.13	1	1
ADA	1	1	1.05	1	1.05	1	1
AK	1	1	1.03	1	1.03	1	1
Total electrophoresis			5.30[d]	44.04%[e]	4.14[d]		
Probability			84.14%[f]		80.57%[f]		
GM	NT[g]	F BO	4.27	F BO	0.00	A, F, X BO, G	NT
KM	NT[g]	3	1.41	3	1.41	3	NT
Total allotypes			6.02[d]	40.77%[e]	0.00		
Probability			85.76%[f]		0.00		
All systems			31.91[d]	17.96%[e]	0.00		
Probability			96.96%[f]				

[a]ISGN, 1987 [7] notation is used for all genetic markers. For PGM1, the following notation was used: 1A = 1+, 1B = 1−, 2A = 2+.

[b]L is the relative likelihood of maternity. $L = X/Y$. X is likelihood of the alleged mother transmitting the allele in question (always between 0.5 and 1.0). Y is the likelihood of it occurring by chance and equals the allele frequency.

[c]NC indicates not calculated, because more informative PGM(SUB) was used.

[d]Combined likelihood of maternity = $L1 \times L2 \times L3 \times \ldots Ln$.

[e]Combined phenotype frequencies of population of potential mothers.

[f]Combined probability of maternity, calculated from the combined likelihood of maternity, assuming a prior probability of 0.5.

[g]NT = not tested.

mother should have been identical, but were not. When immunoglobulin allotype results are combined with the red cell antigen and enzyme system findings, probability calculations establish the deceased woman as the mother of the infant with 96.9% probability (Table 1).

Tissues adherent to the metallic key retrieved from the crime scene were processed for histological examination and found to consist of mature adipose tissue, epithelial cells, skeletal muscle, smooth muscle, and human hair with abundant bacterial and fungal overgrowth. When the car key was positioned next to the incised abdominal wound and adjacent patterned abrasions, it was concluded that the key notches could explain the patterning of the abdominal injury and that the key was the instrument used in executing the crude Cesarean section (Fig. 4).

Since the puncture wounds on the umbilical cord were suggestive of bite marks, full dental casts were obtained from the suspect. The upper central incisors contained sharp inferior edges, while the lower central incisors were typically more blunt. Correspondingly, puncture wounds on some of the umbilical cord surfaces contained relatively sharp margins with little associated abrasion or contusion, while puncture defects on opposing surfaces had conspicuously smaller dimensions and abundant marginal abrasion and contusion. When the suspect's dental cast was aligned with the injuries on the umbilical cord, the puncture wounds closely approximated in size, shape, and placement the left upper central and lower central incisors (Fig. 5). Ultimately, the suspect admitted to having severed the umbilical cord by biting it.

Discussion

The most powerful polymorphic system in routine use for human parentage testing is HLA phenotyping. However, this method is usually unavailable to the forensic serologist who assists in death investigation, because postmortem tissue specimens can rarely be processed in the time required to insure necessary lymphocyte viability [*1*]. Therefore, red blood cell antigen and polymorphic enzyme system evaluations have become the standard paternity and maternity tests employed in forensic science. Specifically, erythrocyte enzyme system population frequencies have been intensely and elaborately studied

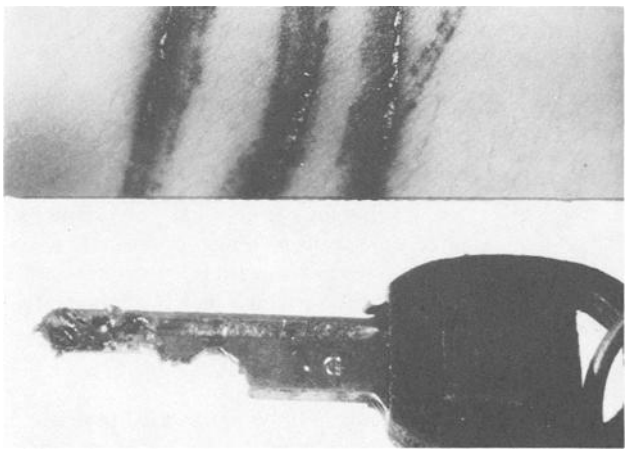

FIG. 4—*Key recovered near the body had blood, adipose, hair, and muscle adherent to its surfaces and is shown juxtaposed to patterned abdominal abrasions.*

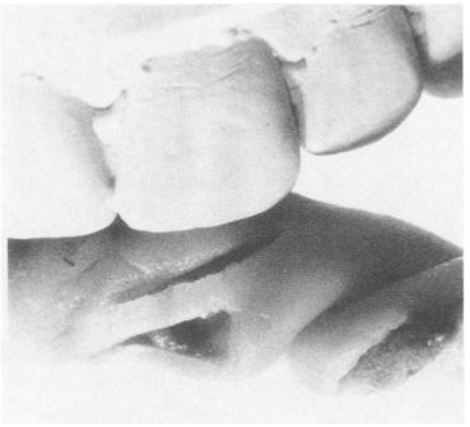

FIG. 5—*Bite marks on portions of distal umbilical cord closely approximate size and shape of suspect's left upper central incisor.*

and effectively used to calculate identification probabilities in many forensic science cases [*2,9–12*].

The exclusion and discrimination power of individual red cell antigens and enzyme systems is dependent on both the degree of polymorphism within a given system and the various system phenotypic frequencies within a population group. The usefulness of a red cell antigen or an enzyme system for forensic application is further determined by its relative stability over time and under highly variable storage conditions. For example, erythrocytic acid phosphotase (ACP [EAP]) is an enzyme system which, because of its degree of polymorphism, has a relatively high exclusion probability of approximately 22% [*12*]. (ACP [EAP]) determination is, however, somewhat limited in its forensic science applications because of degradation susceptibility which can render the enzyme undetectible in whole blood specimens even after one week of storage at body temperature [*4*].

Ideal red cell or serum markers used in forensic science should be both highly polymorphic as well as stable under varied storage conditions. Immunoglobulin (GM and KM) allotyping offers such features and has been effectively utilized in race determinations [*13*] and more recently in cases of disputed parentage [*14*]. Gamma markers (GM) and Kappa markers (KM) refer, respectively, to antigenic sites on heavy and light chain portions of the human immunoglobulin molecule. Allotypes have been demonstrated for the IgG, IgA, and IgE immunoglobulin heavy chains and for Kappa light chains. Within the classes and subclasses of these human immunoglobulin chains, at least 24 separate allotypes have been antigenically identified rendering a high degree of polymorphism [*6,15*]. Furthermore, GM and KM antigen stability has been demonstrated in 30-year-old blood stains [*16*]. The antigens have been shown to be stable to moderate heat and alkali and are unaffected by hemolysis and bacterial contamination [*17*]. In contrast to a number of red cell antigens or enzyme systems which are found only in blood, human immunoglobulins are present throughout the body in varying amounts. GM and KM antigens have been characterized in many body fluids including saliva, nasal secretions, semen, vaginal secretions, and sweat [*6,17*].

In humans, fetal or newborn immunoglobulin is maternal in origin and arrives in the fetus by placental transfer. At birth, immunoglobulin is comprised almost exclusively of IgG, so that a fetal or newborn GM phenotype is identical to that of the mother. Non-maternal gamma globulin has been demonstrated in infants as early as two weeks old,

but in large series, children have been allotype-identical to their mothers in 83% of cases, even up to three months of age [*14*]. This feature establishes GM and KM allotyping as an extremely useful serologic study in disputed maternity cases such as those involving infant abandonment. By six months of age, a child's true immunoglobulin phenotype is well developed and expressed.

Since the discovery of immunoglobulin antigens during the late 1950s, assay methods have been refined and simplified. Microtiter hemagglutination inhibition techniques are presently widely used for immunoglobulin allotyping. Prepared reagents, equipment and typing sera, as well as detailed technical instructions, are commercially available [*6,15,17*].

Conclusion

Recently, forensic science has been introduced to new methods of identification stemming from the rapid evolution of molecular biology technology in the form of deoxyribonucleic acid (DNA) fingerprinting. This technique may eventually provide the ultimate method for forensic science identification; however, DNA fingerprinting is still evolving. The technology is sophisticated and expensive with availability presently limited. The process of individual identification in many forensic science laboratories, therefore, will continue for some time to rely on more traditional serologic analyses of body fluids which include characterization of red blood cell antigens, enzyme systems, and serum proteins. Such tests are well established, proven, and are readily available to the forensic scientist.

The preceding case specifically demonstrates the value of immunoglobulin allotyping in forensic science identification. A high degree of polymorphism, extreme antigen stability, and identical phenotypes within mothers and their newborn infants make immunoglobulin allotyping particularly suited to forensic maternity determination. GM and KM typing is currently performed in forensic science laboratories and is being established in other labs as a routinely available test. As with other serology identification tests, GM and KM typing has been successfully employed in courtroom testimony.

The unusual case herein described produced sufficient circumstantial evidence to implicate the suspect. Ultimately, serologic confirmation in addition to patterned injury evaluation and bite mark analysis were instrumental in obtaining a conviction.

Acknowledgments

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References

[*1*] Miller, W. V. and Rodey, G., *HLA Without Tears*, Educational Products Division, American Society of Clinical Pathologists, Chicago, 1981.

[*2*] Dykes, D. D. and Polesky, H. F., "The Usefulness of Serum Protein and Erythrocyte Enzyme Polymorphisms in Paternity Testing," *American Journal of Clinical Pathology*, Vol. 65, June 1976, pp. 982–990.

[*3*] *Forensic Science Handbook*, R. Saferstein, Ed., Prentice-Hall, Englewood Cliff, NJ, 1982, pp. 358–379.

[*4*] Gaensslen, R. E., *Sourcebook in Forensic Serology, Immunology and Biochemistry*, National Institute of Justice, U.S. Department of Justice, Washington, DC, 1983, pp. 58–60, 305–310, 450–453.

[*5*] *Metropolitan Police Forensic Science Laboratory—Biology Methods Manual*, Commissioner of Police of the Metro Police, Metropolitan Police Forensic Science Laboratory, London, 1978.

[*6*] Schanfield, M. S., *Laboratory Manual for Human Immunoglobulin Allotyping*, Allo-Type Genetic Testing, Inc., Atlanta, GA, 1988.

[7] Shows, T. B., Alpine, P. J., Bouchix, C., et al., "Guideline for Human Gene Nomenclature. An International System for Human Gene Nomenclature," *Cytogenetics Cell Genetics*, Vol. 46, 1987, pp. 11–28.

[8] Schanfield, M. A., Polesky, H. F., and Sebring, E. S. in *GM and INV Type Paternity Testing*, H. F. Polesky, Ed., American Society of Clinical Pathologists, Chicago, 1975, pp. 45–53.

[9] Gaensslen, R. E., Bell, S. C., and Lee, H. C., "Distributions of Genetic Markers in United States Populations: I. Blood Group and Secretor Systems," *Journal of Forensic Sciences*, Vol. 36, No. 4, July 1987, pp. 1016–1058.

[10] Gaensslen, R. E., Bell, S. C., and Lee, H. C., "Distributions of Genetic Markers in United States Populations: II. Isoenzyme Systems," *Journal of Forensic Sciences*, Vol. 32, No. 5, Sept. 1987, pp. 1348–1381.

[11] Gaensslen, R. E., Bell, S. C., and Lee, H. C., "Distributions of Genetic Markers in United States Populations: III. Serum Group Systems and Hemoglobin Variants," *Journal of Forensic Sciences*, Vol. 32, No. 6, Nov. 1987, pp. 1754–1774.

[12] Dykes, D. D., "The Use of Frequency Tables in Parentage Testing," in *Probability of Inclusion in Paternity Testing: A Technical Workshop*, H. Silver, Ed., American Association of Blood Banks, Arlington, 1982, pp. 15–44.

[13] Blanc, M., Gortz, R., and Ducos, J., "The Value of GM Typing for Determining the Racial Origin of Blood Stains," *Journal of Forensic Sciences*, Vol. 16, No. 2, April 1971, pp. 176–182.

[14] Sebring, E. S., Polesky, H. F., and Schanfield, M. S., "GM and KM Allotypes in Disputed Parentage," *American Journal of Clinical Pathology*, Vol. 71, No. 3, March 1979, pp. 281–285.

[15] Schanfield, M. S. and van Loghen, E., "Human Immunoglobulin Allotypes," *Handbook of Experimental Immunology, Vol. 3, Genetics and Molecular Immunology*, P. M. Weir, L. Herzenberg, C. Blackwell, and L. A. Herzenberg, Eds., Blackwell Scientific, Oxford, 1986, pp. 94.1–94.18.

[16] Hoste, B., Brocteur, J., and Andre, A., "Indefinite Storage of Dried GM and KM (INV) Antigens: Examination of Blood Stains 33 Years Old," *Forensic Science*, Vol. 11, 1979, pp. 109–113.

[17] Kipps, A. E., "GM and KM Typing in Forensic Science—A Methods Monograph," *Journal of Forensic Science Society*, Vol. 19, No. 27, 1979, pp. 27–47.

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