OPEN ACCESS
Scholars International Journal of Anatomy and Physiology
Abbreviated Key Title: Sch Int J Anat Physiol
ISSN 2616-8618 (Print) |ISSN 2617-345X (Online)
Scholars Middle East Publishers, Dubai, United Arab Emirates
Journal homepage: https://saudijournals.com

Original Research Article

Embalming of Early Decomposing Strangled Homicides in Anambra State, Nigeria: A Validation Study

Darlington Cyprain Akukwu[1], Darlington Nnamdi Onyejike[2*], Chiamaka Mercy Iwuala[2], Ifeoma Miracle Onyejike[2], Somadina Nnamdi Okeke[2], Ambrose Echefulachi Agulanna[2], Emmanuel Nzube Ezenwatu[2], Emeka Ambrose Okubike[2], Gloria Chinenye Ojemeni[2], Ugochukwu Samuel Aguwa[2]

[1]Department of Anatomy, Faculty of Basic Medical Sciences, Imo state University, Owerri, Imo State, Nigeria
[2]Department of Anatomy, Faculty of Basic Medical Sciences, Nnamdi Azikiwe University, Nnewi Campus, Anambra State, Nigeria

DOI: 10.36348/sijap.2022.v05i05.001 | **Received:** 17.04.2022 | **Accepted:** 13.05.2022 | **Published:** 24.05.2022

***Corresponding author:** Darlington Nnamdi Onyejike
Department of Anatomy, Faculty of Basic Medical Sciences, Nnamdi Azikiwe University, Nnewi Campus, Anambra State, Nigeria

Abstract

Formalin is one of the commonest embalming fluid used in modern embalming. Methanol can also be mixed with formalin in order to prevent the precipitation of formaldehyde to paraformaldehyde. Methanol is also a good preservative. Strangled bodies remain one of common homicides received at funeral homes in Anambra state, Nigeria. Therefore, the objectives of this study are to observe the early decomposition activities in Anambra state; use an embalming mixture containing formalin, methanol and water to arrest it; and document the techniques used to achieve it. Therefore, four infant pigs were used for this study. They were sacrificed and allowed to reach the early stage of decomposition before embalming. The results showed that outcome of embalming is influenced by the embalming mixture used, duration of the embalming, and the room temperature of the morgue were the embalmed bodies were stored after embalming. The results also showed that atmospheric temperature and humidity does not influence the outcome of embalming. In conclusion, the methodology for arresting early decomposition of strangled homicides is by arterially injecting an embalming mixture containing formalin, methanol, water and dye; and also supplementing this technique with hypodermic embalming technique.

Keywords: Commercial embalming, Embalming of decomposing bodies, Embalming homicides, Embalming of strangled bodies, Funeral services, Modern embalming science, Specialist embalming.

INTRODUCTION

Strangulation is one of the commonly reported homicides in Nigeria (Dada, 2021; Local African Reality, 2021; News Express, 2021; The Nation Nigeria, 2019). Often times, homicides resulting from strangulation are discovered very late from its clandestine location during which time, the body must have started decomposing (Dada, 2021). At the time these bodies are brought to the funeral homes for preservation and possible investigation, it becomes difficult for most embalmers or morticians to arrest the decomposition. In addition, there is scarce literature or methodology for arresting early decomposition of strangled bodies.

Formalin embalming is one of the popular modern methods of preserving cadavers either for burial or dissection (Mayer, 2012). Formalin is a very strong preservative with irritating smell (Lakchayapakorn & Watchalayarn, 2010), which can mix with other chemicals to provide a suitable solution for arresting decomposing bodies by inactivating the autolytic enzymes (proteins) and bacteria (Mayer, 2012; Ajmani, 1998). Methanol can also be mixed with formalin in order to stabilize the fluid, and also prevent the precipitation of formaldehyde into paraformaldehyde (Pal *et al.*, 2022; Ajmani, 1998). Methanol may also be used routinely for fixing tissues because it gives good results (Hammer *et al.*, 2012).

A study reported that embalming decomposing bodies resulting from strangulation, burning, stab wounds, accidents, drowning, etc. requires a mixture of formalin, methanol, ammonium salt, thymol, glycerine, and water in order to arrest decomposition (Onyejike *et al.*, 2018). However, this study did not identify the stage of decomposition that could be arrested by this

mixture, and did not provide an experimental account of the procedures required to achieve a successful outcome. Therefore, this study was aimed at carrying out a validity test on the efficacy of an embalming mixture containing formalin, methanol, and water on strangled early decomposing bodies using porcine models (*Sus scrofa domestica*).

METHODS

Ethical approval

The ethical approval was obtained from the ethical committee, Faculty of Basic Medical Science, College of Health, Nnamdi Azikiwe University, Nnewi Campus.

MATERIALS

The materials used for the study include 40% formalin, 10% methanol, water, embalming gravity tank, dissecting kit, surgical gloves, steel tape, digital thermo-hygrometer, Generic digital pH and chemical tester, digital thermometer, suturing needles, 10mL and 20mL syringes, boots, cotton wool, weighing scale, methylated spirit, nose-mask, and digital camera.

Location of the study

This study was carried out at the Gross Anatomy laboratory of the Department of Anatomy, Nnamdi Azikiwe University, Nnewi campus, Nigeria.

Experimental animals

The experimental animals used for the study were four (two males and two females) infant domestic pigs (*Sus scrofa domestica*) because of the ethical issues related to the mode of death of the animals. The animals were procured from a pig farm located very close to the study location. Animals were in healthy condition.

Experimental procedure

This study design was a single-case experimental study design. The concept used for the research procedure was formulated by the researchers. Data on the observable decomposition changes of the animals were collected by the researchers. The peri-mortem and post-mortem body temperatures of the pigs were documented.

Animals were sacrificed by strangulation. Animal death was confirmed when no heart beat was recorded using stethoscope and when there was no pupillary reflex. The exact time of death was recorded. Early visible signs of decomposition (algor mortis, rigor mortis, pallor mortis, livor mortis) were monitored for eight hours. The choice of this timeline is because it is the usual timeline for reporting and delivering strangled homicides to funeral homes in Anambra state. It is also the timeline for early decomposition as indicated by a study on decomposition timeline in this region (Onyejike *et al.*, 2021). After eight hours, the animals were embalmed via cervical arterial embalming and hypodermic embalming methods. Embalming activities were completed when all the body parts were completely fixed. Animals were re-embalmed fourth day and seventh day.

The atmospheric temperature, room temperature, and humidity were recorded from the time of death till the last day of the study. The post embalmment changes were monitored morning, afternoon and night for two weeks and subsequently monitored morning and night till the end of the study. The body structures that were completely fixed where scored whereas the body parts not fixed were not scored.

Method of data collection for daily climate readings

The thermo-hygrometer was placed on the slabs of the dissecting room and the wire extended outside the room via its window. The time was set on the equipment to GMT (+1) to ensure accuracy in documenting the readings. The lowest atmospheric temperature of the day was recorded between 3am and 7am; and the highest atmospheric temperature of the day recorded between 11am and 3pm. The lowest humidity of the day was recorded between 11am and 3pm; and the highest humidity of the day recorded between 3am and 7am.

Method of embalming

The methanol, water and formaldehyde were measured using a measuring cylinder each 1000ml. This means that the embalming mixture used contained 20% formalin and 5% methanol. Water was first measured, and this was followed by the measurement of formalin and methanol. Methanol was measured last because of its high evaporation property.

Single point method of arterial embalming technique was first used via the internal carotid artery (on the neck); and was supplemented by hypodermic embalming technique in order to ensure that the embalming fluid circulated to all the body parts affected by the stab wounds. Later, when fungi were found on the animals, thymol crystals were crushed and added to the mixture then “sprayed” on the animals. The thymol crystals were stirred sparingly until it completely dissolved in the mixture.

Scoring Method

The researchers developed a scoring method for the completely fixed parts of the carrions post-embalming. The completely fixed parts were scored ‘1’, whereas the unfixed parts were either scored ‘0’ or not scored at all. The head and neck body structures that were scored are crown, two ears, two eyes, oral region, snout, dorsal aspect of the neck and ventral aspect of the neck. The body structures of the trunk that were scored are tail, umbilical region, thorax, dorsal aspect of

the trunk and the anorectal region. The four limbs were scored individually.

Experimental precautions

Animals were procured from a farm close to the research facility in order to ensure that there was no change in body thermal condition. Animals were procured very early in the morning between 5am and 6am, and allowed to rest and acclimatize for a period of one hour before sacrifice.

The study avoided parallax error when reading the animal weight on the analogue weighing scale. The thermometer was cleaned with cotton wool and methylated spirit, and dried after every rectal reading to ensure accuracy in data collection.

Statistical analysis

The statistical tool used for this study was SPSS IBM series version 25. The data were descriptively and inferentially analyzed and represented in tables. Pearson correlation was used to test the relationship between outcome of embalmment (represented as body scores – TBS) and embalming fluid (represented as volume of embalming fluid – VEF).

Duration of research

This study lasted for a period of 42 days (from April 2021 to May 2021).

RESULTS AND DISCUSSION

Body statistics of experimental animals

Result obtained from the peri-mortem body statistics of the animals showed that the animals were infants (about six weeks old). The body temperatures of the animals were at optimal levels (Table 1). The body weight of some of one of the animals slightly decreased after eight hours (Table 2). The body weights of all the animals significantly decreased after 42 days (Table 2). This decrease is the resultant effect of formalin leading to mummification of the animals. This is corroborated by a report which noted that 5% and 10% formalin-embalmed pigs mummify at a quick rate (Keaton, 2012).

Visible post-embalming changes

The first sign of decomposition was algor mortis which started 10 minutes after death (Table 3). This was accompanied by discharge of fluid from the anus. Algor mortis was immediately followed by pallor mortis which started 20 minutes after death. Rigor and livor mortises subsequently followed after 30 minutes after death (Table 3; Figure 1). The speedy rate at which algor mortis started and progressed suggests that the strangulation process enhanced the decomposition rate of the animals. This is because a study by Hanna & Moyce (2008) noted that mode of death (such as strangulation) is a factor that accelerates the rate of decomposition.

Other visible post mortem changes observed on the animals within the first eight hours before embalming includes discharge of faecal matter from the anus, discharge of fluid from the oral cavity, putrid odour, and bloating of the trunk (Table 4). This means that the animals reached the early bloat stage of decomposition before they were embalmed. This is because several studies have noted that these visible changes observed in this study are notable signs of fresh stage and early bloat stages of decomposition in the temperate region (Obun *et al.*, 2020; Marais-Werner *et al.*, 2018; Hyde *et al.*, 2013; Biswas, 2012; Megyesi *et al.*, 2005).

After embalming, decomposition gradually slowed down from the second day. By the fourth day, all the animals were still decomposing (Table 5; Figure 2), and this was also manifested in the body scores of the animals (Table 9). By the sixth day, one of the animals was completely fixed and mummified; whereas the other animals became completely fixed and mummified by the eighth day (Table 6; Figure 3). All the animals remained mummified till the last day of the study (Table 7; Figure 4). These post-embalming changes indicate that decomposition gradually slowed down from the second day till the last day of the until all the animals mummified. This validates the potency of the methodology used to embalm the animals. Formalin and methanol have been reported to be effective preservatives which prevent decomposition (Brenner, 2014). In addition, formalin has been reported to dry and mummify carcasses (Keaton, 2012), and prevent microorganisms and arthropods when used for embalming (Richins *et al.*, 1963).

Relationship between the outcome of embalming and independent variables

The dependent variable for this study is the outcome of embalming. The independent variables for this study are the factors that could influence the rate of decomposition which in turn could affect the outcome of embalming. The independent variables include room temperature, humidity, atmospheric temperature, volume of embalming fluid and duration after embalming (Table 8). Pearson correlation analysis showed that there was a statistically significant moderate positive correlation ($r = .546$, $n = 42$, $p = .001$) between outcome of embalming and duration of embalming; a statistically significant moderate negative correlation ($r = -.555$, $n = 42$, $p = .001$) between outcome of embalming and volume of embalming fluid; and a statistically significant weak negative correlation ($r = -.326$, $n = 42$, $p = .001$) between outcome of embalming and room temperature. However, Pearson correlation analysis showed that there was a statistically insignificant very weak positive correlation ($r = .131$, n

= 42, p = .407) between outcome of embalming and humidity; and a statistically insignificant very weak negative correlation (r = -089, n = 42, p = .574) between outcome of embalming and atmospheric temperature.

The outcome of embalming was not influenced by atmospheric temperature and humidity. However, the outcome of embalming was positively influenced by embalming duration; which means that as duration progressed, the animals became more fixed or mummified. The outcome of embalming was also negatively influenced by room temperature and the volume of embalming fluid. This means that lower or optimal room temperatures aid the preservation of burnt carcasses compared to higher or extreme temperatures. More so, the embalming mixture is very reliable because little amount is needed to arrest decomposition of the strangled animals. The constituents of this mixture have been reported to possess strong preservative effects on decomposing bodies (Pal *et al.*, 2022; Onyejike *et al.*, 2018; Brenner, 2014; Bedino, 2003; Richins *et al.*, 1963).

Table 1: Peri-mortem body statistics

BODY STATISTICS	PIG 1	PIG 2	PIG 3	PIG 4
Weight (Kg)	12	12.5	13	12.5
Body Temperature (0C)	39.1	39.2	39.1	39.3
Recumbent Length (cm)	57	60	60	60
Chest Circumference (cm)	37	41	42	41
Waist Circumference (cm)	38	38	39	38
Atmospheric temperature at death (0C)	27.4	27.4	27.5	27.6
Time of death	8:09am	8:10am	8:12am	8:14am

Table 2: Post-mortem body statistics

BODY STATISTICS	PIG 1	PIG 2	PIG 3	PIG 4
Weight after 8 hours (Kg)	11.4	12.5	13.0	12.5
Body temperature after 8 hours (^{0}C)	31.0	31.5	31.5	31.0
Weight at day 42 (Kg)	5.0	5.0	6.0	5.0

Table 3: DAY 1 Data – 10 Minutes Periodic observations after Death

TIME	BT (^{0}C)	AT (^{0}C)	RT (^{0}C)	VISIBLE CHANGES	Insect Activities
8:09am	39.1	27.4	27.7	No pupillary Reflex.	Nil
8:19am	38.3	27.3	27.4	Algor mortis starts.	Nil
8:29am	36.8	27.7	28.4	Fluid discharge from the anus. Temperature continues to drop.	Nil Nil
8:39am	37.1	27.5	27.9	Pallor mortis was starts.	Nil
8:49am	36.6	27.4	28.2	Rigor mortis starts. Livor mortis starts.	Nil
8:59am	37.1	28.2	27.9	Algor, pallor, rigor and livor mortises progressed.	Nil
9:01am	35.7	28.3	28.3	Algor, pallor, rigor and livor mortises progressed.	Nil

BT. Body temperature
AT. Atmospheric temperature
RT. Room temperature

Table 4: DAY 1 Data – Hourly Observation

TIME	BT (^{0}C)	AT (^{0}C)	RT (^{0}C)	VISIBLE CHANGES	Insect Activities
10:09am	32.7	30.2	29.2	Algor, pallor, rigor and livor mortises progressed.	Nil
11:09am	31.0	30.4	29.8	Discharge of faecal matter from the anus.	Nil
12:09pm	31.0	33.1	30.9	Algor mortis became fixed.	Nil
1:09pm	31.0	34.2	31.8	Increase in intra-abdominal pressure.	Nil
2:09pm	31.0	36.5	32.5	The abdomen continues to bloat; Pallor, rigor and livor mortises progressed.	Nil
3:09pm	31.0	37.8	33.4	Pallor mortis became fixed	Nil
4:09pm	31.0	34.9	33.6	Discharge of fluid from the oral cavity; Livor mortis became fixed; Rigor mortis progressed; Bloating of abdomen progresses with putrid odour.	Nil

BT. Body temperature
AT. Atmospheric temperature
RT. Room temperature

Table 5: DAY 4 Post-embalming visible changes

Time	Head & neck visible changes	Trunk visible changes	Limbs visible changes
Morning (6.17am)	All the structures of the head and neck were completely fixed and mummified except the lips and one of the eyelids.	The umbilical region appeared bloated and decomposing. Other structures of the trunk were completely fixed and mummified.	Decomposition gradually slowed down at the four limbs.
Afternoon (12.09pm)	No visible change different from what was observed in the morning.	No visible change different from what was observed in the morning.	No visible change different from what was observed in the morning.
Evening (6.05am)	No visible change different from what was observed in the afternoon.	Discharge of black matter from the anus.	Dark-brown discolouration of the forelimbs.

Table 6: DAY 7 Post-embalming visible changes

Time	Head & neck visible changes	Trunk visible changes	Limbs visible changes
Morning (6.17am)	All the structures of the head and neck region were completely fixed.	All structures of the trunk were completely fixed.	All the limbs were completely fixed.
Afternoon (12.00pm)	No visible changes.	No visible changes.	No visible changes.
Evening (6.00pm)	No visible changes.	No visible changes.	No visible changes.

Table 7: DAY 42 Post-embalming visible changes

Time	Head & neck visible changes	Trunk visible changes	Limbs visible changes
Morning (6.12am)	All the structures of the head and neck region remained mummified.	All structures of the trunk remained mummified.	All the limbs were mummified.
Evening (6.20pm)	No visible changes.	No visible changes.	No visible changes.

Table 8: Pearson Correlation between the outcome of embalming and all the independent variables used for the study

		Days of Embalming	Average Atmospheric Temp.	Average Humidity	Average Room temp.	Average Total Post-Embalming Body Score	Average VEF
Average Total Body Score (Outcome of embalming)	Pearson Correlation	.546**	-.089	.131	-.326*	1	-.555**
	Sig. (2-tailed)	.000	.574	.407	.035		.000
	N	42	42	42	42	42	42
*. Correlation is significant at the .05 level (2-tailed). **. Correlation is significant at the .01 level (2-tailed).							

KEY TO QUALITY OF RELATIONSHIP
0.80 – 1.00 Very strong positive
0.60 – 0.79 Strong Positive
0.40 – 0.59 Moderate positive
0.20 – 0.39 Weak positive
0.00 – 0.19 Very weak positive

Table 9: Post-embalming body scores (outcome of embalming) of the pigs and Volume of embalming fluid applied

DAY	TPBS 1	TPBS 2	TPBS 3	TPBS 4	CTPBS	ATPBS	VEF 1 (ml)	VEF 2 (ml)	VEF 3 (ml)	VEF 4 (ml)
1	0	0	0	0	0	0	1600	1600	1600	1600
2	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0
4	9	0	4	5	18	4.5	500	500	500	500
5	13	15	11	17	56	14	0	0	0	0
6	14	18	15	17	64	16	0	0	0	0
7	18	18	18	18	72	18	150	150	150	150
8	18	18	18	18	72	18	0	0	0	0
9	18	18	18	18	72	18	0	0	0	0
10	18	18	18	18	72	18	0	0	0	0
11	18	18	18	18	72	18	0	0	0	0
12	18	18	18	18	72	18	0	0	0	0
13	18	18	18	18	72	18	0	0	0	0
14	18	18	18	18	72	18	0	0	0	0
15	18	18	18	18	72	18	0	0	0	0
16	18	18	18	18	72	18	0	0	0	0
17	18	18	18	18	72	18	0	0	0	0
18	18	18	18	18	72	18	0	0	0	0
19	18	18	18	18	72	18	0	0	0	0
20	18	18	18	18	72	18	0	0	0	0
21	18	18	18	18	72	18	100	100	100	100
22	18	18	18	18	72	18	100	100	100	100
23	18	18	18	18	72	18	100	100	100	100
24	18	18	18	18	72	18	0	0	0	0
25	18	18	18	18	72	18	0	0	0	0
26	18	18	18	18	72	18	0	0	0	0
27	18	18	18	18	72	18	0	0	0	0
28	18	18	18	18	72	18	0	0	0	0
29	18	18	18	18	72	18	0	0	0	0
30	18	18	18	18	72	18	0	0	0	0
31	18	18	18	18	72	18	0	0	0	0
32	18	18	18	18	72	18	0	0	0	0
33	18	18	18	18	72	18	0	0	0	0
34	18	18	18	18	72	18	0	0	0	0
35	18	18	18	18	72	18	0	0	0	0
36	18	18	18	18	72	18	0	0	0	0
37	18	18	18	18	72	18	0	0	0	0
38	18	18	18	18	72	18	0	0	0	0
39	18	18	18	18	72	18	0	0	0	0
40	18	18	18	18	72	18	0	0	0	0
41	18	18	18	18	72	18	0	0	0	0
42	18	18	18	18	72	18	0	0	0	0

TPBS 1. Total post-embalming body scores for Pig 1
TPBS 2. Total post-embalming body scores for Pig 2
TPBS 3. Total post-embalming body scores for Pig 3
TPBS 4. Total post-embalming body scores for Pig 4
CTPBS. Cumulative total post-embalming body scores
ATPBS. Average total post-embalming body scores
VEF 1. Volume of embalming fluid used to fix Pig 1
VEF 2. Volume of embalming fluid used to fix Pig 2
VEF 3. Volume of embalming fluid used to fix Pig 3
VEF 4. Volume of embalming fluid used to fix Pig 4

Table 10: Climatic factors that influence decomposition

DAY	HAT (^{0}C)	LAT (^{0}C)	HH (%)	LH (%)	HRT (^{0}C)	LRT (^{0}C)
1	38.4	27.8	92	63	33.9	28.1
2	30.1	22.4	98	77	33.4	24.1
3	30.1	22.5	92	72	30.0	24.5
4	32.6	24.0	94	65	30.6	25.8
5	32.4	24.8	96	65	31.9	26.0
6	33.4	25.4	92	52	32.2	26.9
7	33.4	26.5	88	65	31.0	28.3
8	34.2	23.6	93	74	31.1	24.1
9	29.4	24.1	95	74	29.0	23.6
10	30.3	23.0	94	62	29.7	23.4
11	33.4	24.4	96	70	31.1	23.7
12	34.6	23.2	94	69	31.2	24.1
13	40.0	23.6	90	65	32.4	23.4
14	39.4	24.5	93	53	33.5	23.9
15	33.5	22.3	97	71	31.2	23.5
16	33.3	23.6	97	69	31.2	23.2
17	34.0	23.1	92	66	32.3	23.8
18	33.9	22.9	98	76	30.9	23.1
19	34.8	24.1	94	68	31.5	23.7
20	34.0	22.7	95	66	30.0	23.9
21	31.2	21.5	99	77	23.5	23.1
22	31.6	22.7	93	74	29.8	24.8
23	30.6	22.2	96	77	28.9	24.1
24	32.0	22.1	97	76	29.9	23.4
25	31.6	23.4	95	72	30.8	23.9
26	35.4	23.7	98	69	32.3	24.1
27	26.8	21.2	99	87	25.7	23.1
28	32.1	22.1	99	72	29.8	24.6
29	32.5	24.4	97	70	30.4	29.0
30	32.2	24.7	94	72	30.2	26.2
31	32.7	24.8	91	69	30.1	26.1
32	32.5	25.4	92	77	29.7	26.7
33	27.5	24.4	99	91	28.5	25.8
34	31.2	25.1	99	90	30.1	26.2
35	27.6	22.1	92	88	27.1	24.4
36	31.5	23.5	95	77	29.0	24.6
37	26.8	21.8	89	80	26.2	23.4
38	30.9	23.4	97	75	29.4	24.4
39	33.2	24.4	84	68	30.5	26.1
40	31.8	26.3	98	75	30.7	27.4
41	31.9	24.5	92	80	29.9	27.1
42	30.8	24.5	95	79	29.9	26.2

HAT. Highest atmospheric temperature
LAT. Lowest atmospheric temperature
HH. Highest humidity
LH. Lowest humidity
HRT. Highest room temperature
LRT. Lowest room temperature

Figure 1: Day 1 – After embalming

Figure 2: Day 4 Post-embalming changes

Figure 3: Day 7 Post-embalming

Figure 4: Day 42 Post-embalming

CONCLUSIONS

This study has validated the effectiveness of an embalming mixture containing formalin, methanol, and water in arresting early decomposition of strangled carcasses. In addition, arterial embalming technique should be supplemented by hypodermic embalming technique in order to ensure that arterial fluid is successfully distributed to areas that were not treated during arterial embalming. Hypodermic technique should also be employed as a post-management approach for a successful outcome.

RECOMMENDATIONS

Based on the findings of this study, the following can be recommended:

- Eosin dye should be added to the mixture identified in this study when embalming human cadavers in order to maintain the dermal colour.
- Further studies should be carried out on the effect of this embalming mixture on adult (matured) domestic pigs at the late bloat stage of decomposition.

REFERENCES

- Ajmani, M. L. (1998). *Embalming: Principle and legal aspects* (1st ed.). Jaypee Brothers Medical Publishers.
- Bedino, J. (2003). Embalming Chemistry: Glutaraldehyde Versus Formaldehyde. *Champion Expanding Encyclopedia of Mortuary Practices, 649*, 2614–2632.
- Biswas, G. (2012). *Review of Forensic Medicine and Toxicology*. JP Medical Ltd.
- Brenner, E. (2014). Human body preservation - old and new techniques. *Journal of Anatomy, 224* (3), 316 – 344.
- Dada, A. (2021, August 2) Motorcyclist strangled to death and his body dumped in an uncompleted building in Delta. *Within Nigeria*. Motorcyclist strangled to death and his body dumped in an uncompleted building in Delta (withinnigeria.com).
- Hammer, N., Loffler, S., Feja, C., Sandrock, M., Schmidt, W., Bechmann, I., & Steinke, H. (2012). Ethanol-glycerin fixation with thymol conservation: a potential alternative to formaldehyde and phenol embalming. *Anatomical Sciences Education, 5*, 225–233.
- Hanna, J. & Moyce, A. (2008). *Factors affecting human decomposition*. (2nd ed.). Invest Publishers.
- Hyde, E., Haarmann, D., Lynne, A., & Bucheli, S. (2013) The Living Dead: Bacterial Community structure of a cadaver at the onset and end of the bloat stage of decomposition. *PLoS one, 8* (10), e77733.
- Keaton, M. A. (2012). Effect of embalming on the decomposition of pigs [Master's dissertation]. LSU Digital Commons. (etd-04092012-194710).
- Lakchayapakorn, K., & Watchalayarn, P. (2010). Formaldehyde exposure of medical students and instructors and clinical symptoms during gross anatomy laboratory in Thammasat University. *Journal of the Medical Association of Thailand*, *93*(7), S92–S98.
- Local African Reality. (2021, April 17) Anambra: How I strangled creditor disturbing me to repay N100,000 – Suspect. *Local African Reality.* Anambra: How I strangled creditor disturbing me to repay N100,000 - Suspect - LOCAL AFRICAN REALITY.
- Marais-Werner, A., Myburgh, J., Becker, P., & Steyn, M. A. (2018). Comparison between decomposition rates of buried and surface remains in a temperate region of South Africa. *International Journal of Legal Medicine*, *132*, 301–309.
- Mayer, R. G. (2012). *Embalming: history, theory, and practice* (5th ed.). McGraw-Hill.

- Megyesi, M., Nawrocki, S., & Haskell, N. (2005). Using accumulated degree-days to estimate the postmortem interval from decomposed human remains. *Journal of Forensic Sciences, 50*(3), 618–626.
- News Express. (2021, August 3) Popular Abuja Millionaire strangled to death at home. *News Express.* Popular Abuja Millionaire strangled to death at home - News Express Nigeria (newsexpressngr.com).
- Obun, C. O., Ogan, C. A., Esomonu, U. G., Nandi, M. E., Uchechukwu, G. O., & Inaku, G. E. (2020). The Effect of Embalmming and Insect Activity on the Decomposition Timeline of Carrion in a Tropical Nigerian Climate. *Journal of Forensic Crime Studies*, *3*(1), 1–10.
- Onyejike, D. (2021). *Comparison of the decomposition timeline of Sus scrofa domestica in rainforest and savannah vegetations of Nigeria* (Unpublished Doctoral dissertation]. University of Calabar.
- Onyejike, D., Ukoha, U., & Aladeyelu, S. (2018). Evaluating the Embalming Procedures of Putrefying Bodies in Relation to Gender in Anambra State, Nigeria. *International Invention of Scientific Journal, 2*(6), 213–222.
- Pal, A. K., Bhanarkar, U. P., & Ray, B. (2022). Embalming with Formalin – Benefits and Pitfalls. *Scholars International Journal of Anatomy and Physiology*, *5*(3), 70–77.
- Richins, C., Roberts, E., & Zeilmann, J. (1963). Improved fluids for anatomical embalming and storage. *The Anatomical Record*, *146*, 241–243.
- The Nation Nigeria. (2019, June 8). FRSC officer strangled to death by colleagues in Anambra. *The Nation Nigeria.* Colleagues strangle FRSC officer to death - The Nation Newspaper (thenationonlineng.net).