ZVONIMIR MAJIĆ, B.Eng.
E-mail: zvonimir.majic@pliva.com
Pliva Croatia Ltd.
Prilaz baruna Filipovića 25, 10150 Zagreb, Croatia
IRENA JUKIĆ, MD
E-mail: irena.jukic@hztm.hr
TOMISLAV VUK, MD
E-mail: tomislav.vuk@hztm.hr
Croatian Institute of Transfusion Medicine
Petrova 3, 10000 Zagreb, Croatia
STANISLAV PAVLIN, Ph.D.
E-mail: stanislav.pavlin@fpz.hr
University of Zagreb
Faculty of Transport and Traffic Sciences
Vukelićeva 4, 10000 Zagreb, Croatia

Distribution Logistics
Preliminary Communication
Accepted: June 7, 2010
Approved: Nov. 15, 2011

RESEARCH OF THE INFLUENCE OF AIR TRANSPORTATION ON BLOOD SAMPLE QUALITY

ABSTRACT

In air freight industry, blood samples are classified as time and temperature sensitive biologically produced pharmaceuticals. To determine the level of influence that the handling processes and air transportation have on blood sample quality, a research has been conducted through transportation of whole blood samples on two European scheduled routes. Two shipping models were defined: the standard one without defined transportation temperature regime and the controlled one, where transportation is conducted under appropriate temperature regime. The blood samples were packed and transported respecting all relevant national and international regulations. The analysis was conducted and the results compared to control sample kept in the laboratory. Significant changes were identified on all components analyzed after crosschecking with the control sample.

KEY WORDS

regulatory issues, blood sample quality, shipping model, packaging instruction, temperature profiles

1. INTRODUCTION

The Act on Blood and Blood Components [1] (*Croatian Parliament, 30 June 2006, Official Gazette No. 79/06*) Chapter VII Export and import of blood and blood samples, in Articles 24 and 25 has issued a prohibition of exporting and importing blood and blood components into and out of the Republic of Croatia. At the same time, both Articles stipulate also special circumstances in which the respective Ministry can exceptionally give clearance for the export, i.e. import of blood and blood components. Unlike blood components, blood samples are relatively often subject of transport, mainly air transport, in order to implement testing or research. All samples have to be non-reactive to the markers of transfusion-transmitted infection diseases. For the needs of the respective research there has been a request to obtain clearance to use blood samples of non-related volunteer blood donors who have been informed about the research and have voluntarily given their written consent to participate in the research. The request for implementation of the research was submitted to the Ethical Committee of the Croatian Institute of Transfusion Medicine (*Hrvatski zavod za transfuzijsku medicinu, HZTM*). By issuing a positive opinion of the Committee the legal assumptions were met to start the research project.

According to a defined protocol the blood samples were extracted from the pre-donation bags with a documented prior consent of the donor. Apart from the mentioned Act, the research procedure recognised also all the other valid acts and regulations related to the distribution of blood and blood components in international transport [2], [3]. The distribution channel which includes also the transportation has been regulated by the national and international documents on good manufacturing, storage and distribution practice [4], [5], [6]. The conditions of air transport handling have been defined by the documents of the Interna-

tional Air Traffic Associations (*IATA*) and the International Civil Aviation Association (*ICAO*).

In compliance with the Act on Blood and Blood Components, Regulations on the Blood Component Traceability System and Monitoring of Serious Adverse Events and Serious Adverse Reactions (*NN 63/07*), Regulations on Quality Assurance of Blood and Blood Components in Medical Institutions (*NN 80/07*), Regulations on Special Technical Requirements for Blood and Blood Components (*NN 80/07*) and finally the quality assurance procedures, after identification, all the donors were tested to determine the level of haemoglobin, they underwent a medical check and had an interview with the authorized physician who was in charge of examining the donors. The physician informed them about the planned research and asked them to sign the form of consent. The person who performs venepunction used the standard procedure following venipuncture to fill the pre-donation bags.

The blood from the pre-donation bag served to isolate the sample for the regulated test and to isolate the first amount of blood which may have contained bacteria contamination from the skin surface at the point of puncture. All the procedures from the entry of the donor, check and venipuncture were done in compliance with the stipulated work instructions that are part of the quality system documentation of HZTM. The samples for immune-haematological test and test for markers of transfusion-transmitted infection diseases were sent to the laboratories where they were subjected to the tests subscribed according to the professional rules and stipulated work instructions. All samples for this research were sent to the Department of Quality Assurance and Control and were tested for the desired haematological parameters in accordance with the respective work instructions.

2. DEFINITION OF PARTICIPANTS, OBJECTIVES, AND DYNAMICS OF THE RESEARCH PROJECT

During observation of the technological process of handling biological samples in air transport, which means also the realisation of the transport task, it is necessary to distinguish the subjects i.e. participants within the very process, to define their role and to determine the responsibility areas as well as the transition points [7]. The responsibility of each participant has been defined in the documents that regulate the relations regarding the transport of perishable and temperature sensitive shipments [8] (*IATA, Perishable Cargo Regulations, 8th Edition*), as well as in the documents that regulate the transport of dangerous goods [9] (*IATA, Dangerous Goods Regulations, 50th Edition*) since biological samples, according to their character may be subject of the latter regulation. In the segment of responsibility, the technological process of transporting biological samples has been passing through four different areas of stakeholder's responsibility in interdependence and interaction. Thus, in the realization of the project, in this concrete case, there are the shipper, the logistic operator, the carrier and the consignee. Starting from the fact that the basic objective was the intention of proving the significant impact of air transport environment on the quality of blood samples, the following project sub-objectives were defined:

- Realization of the legal obligations as preconditions to start a research project.
- Extraction of blood samples at HZTM.
- Haematological analysis of extracted samples at HZTM.
- Realization of the export transportation task.
- Realization of the import transportation task.
- Haematological analysis of the extracted samples at HZTM.
- Systematization and publishing of the collected results.

The conditions under which a blood sample remains in its original quality are strictly defined. A control sample is kept under controlled conditions at +4 °C during storage at HZTM. The temperature regime required for transportation of blood samples is +2 °C to +8 °C defined as cold. This temperature range is considered as controlled transportation conditions. In order to subject the samples to realistic handling and transportation conditions, a part of the samples prepared is transported in standard transportation conditions referred to as uncontrolled conditions.

The project was realized according to the pre-defined protocol through several transport tasks. The number of deliveries in the project was determined by the conclusions deduced from each previous one. The tasks of each single stakeholder in the realization process have been precisely determined by activities in the given time and at the given locality. A detailed presentation of the realization was framed in the form of Standard Operating Procedure[1]. The agreement among stakeholders within the defined technological process regarding technology of the transport task realisation, time and location of performance as well as points of responsibility transition represents the precondition for successful realization. The clarity of the defined objective, sub-objectives, tasks and procedures planned in every segment of the project realization were intended to achieve high level of success in realization.

For the data on the blood sample quality collected during the transportation procedure to be reference-comparable, the realization was carried out according to the model presented in Diagram 1. This diagram shows the process of sending the blood samples to

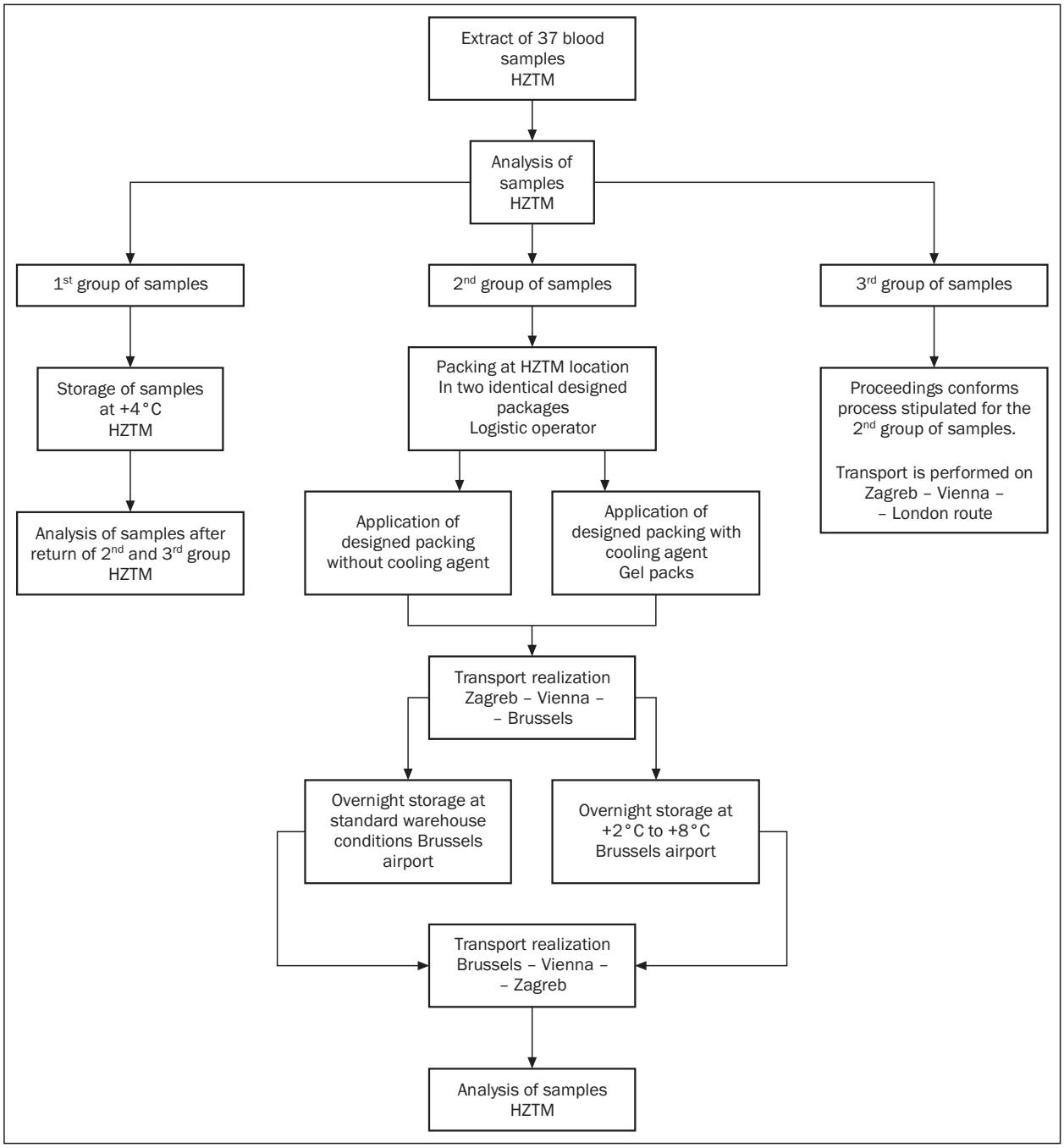

Figure 1 – Transport task realization model

two different destinations in two different regimes. The criteria for carrier selection are a total of 1,052 blood sample shipments transported from the Zagreb Airport during the year 2007 [10]. The routes and destinations were selected according to the same criteria thus applying regular handling and transportation flows applicable at the Zagreb airport.

The first model is denoted as Model A and represents the realization of the transportation task using a scheduled flight from Zagreb via Vienna to Brussels and back, whereas in the second Model (Model B) London was planned as the international destination.

3. REALIZATION OF TRANSPORT TASK AND COLLECTED DATA PROCESSING

The data collected from the realization were systematised in two groups. The first group of data comprised observations and measurements recorded during the realization of the technological process of transport, and the second one included observations regarding the phenomena related to the changes in the structure and quality of blood sample as subject of transport. The realization was carried out according to a pre-defined and from all the stakeholders accepted

Table 1 - Module A, realization of the transport task in the project

Operation title	Responsible stakeholder	Date of execution	Time of execution	Execution location	Location temperature	Storage			
						Time	Temp.	Duration (h)	Location
Blood samples collection and testing	HZTM	10.03.2009	08:00-15:00	HZTM	Ambient[2]	08:00-15:00	+4°C	07:00	HZTM
Storage at production line	HZTM	10.03.2009--11.03.2009	08:00/10.03.09 until 11:00/11.03.09.	HZTM	+4°C	08:00/10.03.09 until 11:00/11.03.09.	+4°C	Up to 27	HZTM
Packing	Logistic operator	11.03.2009	11:00	HZTM	Ambient	11:00	Ambient	00:30	HZTM
HZTM-ZAG Airport road transportation	Logistic operator	11.03.2009	11:30-12:30	Road transport	Ambient	11:30	Ambient	01:00	Road vehicle
Customs clearance	Logistic operator	11.03.2009	12:30-13:30	ZAG Airport	Storage at +4°C	12:30	Ambient and +4°C	02:45	ZAG Airport
Air transport ZAG-VIE	Flight number	11.03.2009	15:15-16:20	On board	Ambient	15:15	Ambient	01:05h	Aircraft compartment
QRT at transit station[3]	Transit station	11.03.2009	16:20-17:30	VIE Airport ramp	Environmental[4]	0	NO	0	0
Air transport VIE-BRU	Flight number	11.03.2009	17:30-19:25	On board	Ambient	17:30	Ambient	01:55	Aircraft compartment
BRU Airport storage	Carrier (handling agent)	11.03.2009	19:25	BRU Airport	Ambient and +4°C	19:25	Ambient and +4°C	14:15	BRU Airport
Air transport BRU-VIE	Flight number	12.03.2009	10:40-12:35	On board	Ambient	10:40	Ambient	01:55	Aircraft compartment
QRT at transit station	Transit station	12.03.2009	12:35-13:35	VIE Airport ramp	Environmental	0	NO	0	0
Air transport VIE-ZAG	Flight number	12.03.2009	13:35-14:35	On board	Ambient	13:35	Ambient	01:00	Aircraft compartment
Customs clearance	Logistic operator	12.03.2009	14:35-15:35	ZAG Airport	Storage at +4°C	14:35	Ambient and +4°C	01:00	ZAG Airport
ZAG Airport-HZTM road transportation	Logistic operator	12.03.2009	15:30-16:30	Road transport	Ambient	14:30	Ambient	01:00	Road vehicle
Blood samples testing	HZTM	12.03.2009	16:30	HZTM	Ambient	16:30	Ambient and +4°C	06:00	HZTM

Table 2 - Example of presentation of measurement results and processing of one of the analysis parameters (number of erythrocytes)

ID No.	1st day[6]	HZTM[7]	BRU K[8]	BRU N[9]	LON K[10]	LON N[11]
D0902401	4.69	4.67	4.66	4.68	4.63	4.65
D0902409	5.19	5.26	5.18	5.22	5.18	5.17
D0902410	5.62	5.56	5.64	5.76	5.61	5.71
D0902411	4.93	4.87	4.85	4.9	4.89	4.97
D0902413	5.06	5	5.06	5.04	5.09	4.99
D0902414	4.32	4.41	4.28	4.37	4.36	4.3
D0902415	5.49	5.32	5.41	5.44	5.37	5.5
D0902416	4.92	4.9	4.96	5.05	4.85	4.98
D0902417	4.93	4.88	5	4.88	4.89	4.91
D0902419	5.25	5.22	5.25	5.38	5.3	5.23
D0902421	4.6	4.59	4.6	4.61	4.56	4.56
D0902423	4.43	4.47	4.58	4.47	4.52	4.43
D0902424	5.21	5.23	5.24	5.32	5.23	5.22
D0902425	5.14	5.14	5.17	5.2	5.23	5.2
D0902426	4.51	4.56	4.59	4.52	4.48	4.54
D0902427	4.59	4.52	4.59	4.58	4.61	4.71
D0902403	5.13	5.13	5.2	5.1	5.01	5.22
D0902404	5.82	5.81	5.76	5.84	5.84	5.79
D0902405	4.39	4.37	4.27	4.27	4.32	4.28
D0902428	5.13	5.18	5.08	5.2	5.12	5.08
D0902429	5.25	5.25	5.21	5.21	5.22	5.19
D0902431	5.52	5.53	5.5	5.6	5.56	5.62
D0902433	5	5.04	4.95	5.02	4.94	4.98
D0902435	4.41	4.4	4.41	4.43	4.44	4.4
D0902436	5.11	5.1	5.04	5.02	5.17	5.09
D0902438	4.98	5.03	4.95	4.94	5.07	5.1
D0902439	4.26	4.26	4.32	4.29	4.39	4.34
D0902440	4.67	4.72	4.73	4.67	4.73	4.78
D0902441	5.03	4.88	5.03	5	4.92	4.9
D0902442	4.84	4.88	4.93	4.85	4.8	4.83
D0902443	4.76	4.8	4.9	4.7	4.48	4.74
D0902444	4.57	4.78	4.84	4.79	4.78	4.85
D0902445	4.96	4.96	4.94	5.04	4.98	4.94
D0902446	4.84	4.88	4.89	4.94	4.72	4.84
D0902447	4.63	4.79	4.88	4.75	4.87	4.82
D0902448	5.44	5.4	5.36	5.51	5.43	5.4
D0902449	5.1	5.08	5.18	5.16	5.07	5.14
D0902450	5	5	5.05	5.11	5.02	5.04
mean[12]	4.94	4.94	4.96	4.97	4.94	4.96
stdev[13]	0.37	0.35	0.35	0.39	0.37	0.37
t(1.day)[14]	-	0.725263018	0.15133582	0.014194363	0.944728359	0.152527379
t(HZTM)[15]	-	-	0.167876061	0.037658316	0.715490216	0.220356639
t(flight)[16]	-	-	-	0.453702836	-	0.138557959

Table 3 - Values of hematocrits, total amount of haemoglobin, amount of haemoglobin in supernatant, and the results of haemolysis

Dose No.	Sample type	Htc[17] %	Hg. total[18]	Hg. u super.[19]	% haemolysis[20]
D0902401	VK	40.2	144	0.8	0.33
D0902409	VK	40.1	137	0.8	0.35
D0902410	VK	46.5	167	2	0.64
D0902411	VK	41.4	148	0.8	0.32
D0902413	VK	41.4	141	0.8	0.33
D0902414	VK	39.3	138	0.6	0.26
D0902415	VK	45.4	160	1.5	0.51
D0902416	VK	40.4	145	1.1	0.45
D0902417	VK	45.3	164	1.2	0.40
D0902419	VK	41.1	149	0.8	0.32
D0902421	VK	41.4	148	1.4	0.55
D0902423	VK	40.7	141	0.4	0.17
D0902424	VK	43.7	153	0.8	0.29
D0902425	VK	43	153	0.5	0.19
D0902426	VK	38.6	136	0.9	0.41
D0902427	VK	37.7	136	1	0.46
D0902403	VK	43.8	153	0.3	0.11
D0902404	VK	39	127	3.9	1.87
D0902405	VK	36.1	125	0.5	0.26
D0902428	VK	40.9	138	1.3	0.56
D0902429	VK	43.1	153	1.5	0.56
D0902431	VK	44.1	156	0.5	0.18
D0902433	VK	40.8	143	0.3	0.12
D0902435	VK	40.2	137	0.2	0.09
D0902436	VK	42.6	150	0.5	0.19
D0902438	VK	41.6	156	0.7	0.26
D0902439	VK	39.2	142	0.3	0.13
D0902440	VK	39.4	141	0.3	0.13
D0902441	VK	42.5	150	0.7	0.27
D0902442	VK	41.7	149	0.7	0.27
D0902443	VK	41.8	147	0.5	0.20
D0902444	VK	39.5	145	0.6	0.25
D0902445	VK	41.8	151	1.1	0.42
D0902446	VK	41.8	151	0.8	0.31
D0902447	VK	38.9	139	1.2	0.53
D0902448	VK	43.1	146	0.6	0.23
D0902449	VK	43.1	152	0.7	0.26
D0902450	VK	41.9	153	0.9	0.34

CONTROL BLOODS[21]:

Low; Lot:84730 / Exp.:12.2009 / Standard values: 0,8+/-0,3g/L

Medium; Lot:84731 / Exp.:12.2009. / Standard values: 5,1+/-0,5g/L

High; Lot:84732 / Exp.:12.2009. / Standard values: 20,4+/-2,0g/L

Microcuvettes[22]:

Lot: 8040160

Exp.: 02.04.2009.

Table 4 - Results of statistical processing of the haemolysis amount

	HZTM	BRU K	BRU N	LON K	LON N
Mean value	0.28	0.32	0.37	0.31	0.40
Standard deviation	0.13	0.15	0.17	0.14	0.19
ttest (HZTM)	-	0.013	1.2×10^{-5}	0.031	8.7×10^{-6}
ttest (flight)	-	0.00013		0.00027	

SOP, with a more concrete presentation of the realization of one of the models (*Table 1*).

The second group of observations referred to the phenomena related to the change in the structure and quality of blood sample as the subject of transport. Vein bloods of donors were extracted from a test tube with K_2EDTA[5] (5.4 mg) a' 3 mL. Five identical samples each were taken from 37 donors. The samples were distributed in three groups. One remained at HZTM (controlled conditions in a refrigerator), the second was packaged for transport via Vienna to Brussels, and the third via Vienna to London in compliance with the pre-defined algorithm. Among samples that were grouped as reference group that remained at HZTM the following parameters were measured immediately upon drawing the blood: number of leucocytes, number of leucocytes of neutrophyl line, number of erythrocytes, haemoglobin amount, value of hematocrit, mean volume of erythrocytes, mean content of haemoglobin in erythrocytes, mean concentration of haemoglobin in erythrocytes, number of thrombocytes, mean volume of thrombocytes. With all the performed tests the lots of microcuvettes and control bloods used in the measurements were recorded. The abovementioned parameters and the haemolysis of erythrocytes have been measured in groups that after the transport were returned to HZTM, which was done immediately upon return. Then the measurement of the control group that was stored in controlled conditions in the HZTM refrigerator was repeated.

An example of the presentation of measurements and processing of the obtained results for one of the groups (controlled transport conditions to London) and the results of haemolysis are presented in *Table 3*. The presented values of hematocrits in the percentage and in total amount of haemoglobin were measured just after drawing blood. The following column shows the values of haemoglobin measured in supernatant after the blood samples have been returned from London. and finally the calculation of the amount of haemolysis expressed in percentage has been presented. At the bottom of the table the lots of microcuvettes and control bloods used in the measurements are presented.

The obtained results were processed statistically, according to groups and compared. For each group of samples the mean value and standard deviation have been calculated for each required parameter. A calculation of t-test has also been performed showing whether there is statistical significance in the difference of the obtained results. The statistically significant difference is considered to be if the result of t-test is < 0.05.

The presented results show that there was a statistically significant difference in the comparison of results obtained from blood which were subjected to the process of transportation, either in controlled or in non-controlled conditions, and those stored at HZTM with the results obtained from the blood samples measured immediately upon drawing blood.

Table 4 shows the results of the statistical processing of the data obtained by measuring the amount of erythrocytes haemolysis.

Comparing the results of the transported blood with the one stored at HZTM, there was also statistically significant difference found in all the determined parameters. There was also statistically significant difference noticed in the results among samples subjected to transport in controlled and non-controlled conditions on the flights to Brussels and London.

4. RECORDINGS OF MEASUREMENT INSTRUMENTS DURING TRANSPORT TASK REALIZATION

During the realization of the transport task in order to determine the temperature profile of realization [11], [12], the temperature measurement instruments have been used[23]. Temperature monitoring has been done in such a way that for every packaging of blood samples two instruments each have been used; one being located on the packaging itself on the outside, and the other one inside the packaging (*Figure 2*).

External measuring instrument was installed on top of the box in order to measure the temperature that develops during sample handling. The latter can be understood as reference in relation to the measured values of ambient temperature for the time when during the processing the shipment was exposed to ambient atmosphere influences. The interior measurement instrument was installed after having set a layer of paper tissues around the primary packaging of the sample. In this way the instrument set within the packaging was not in direct contact with the samples, but the temperature recordings were showing the temperature profile within the packaging. The paper tissues were used as an absorbing and cushioning material within the package in compliance with the provisions

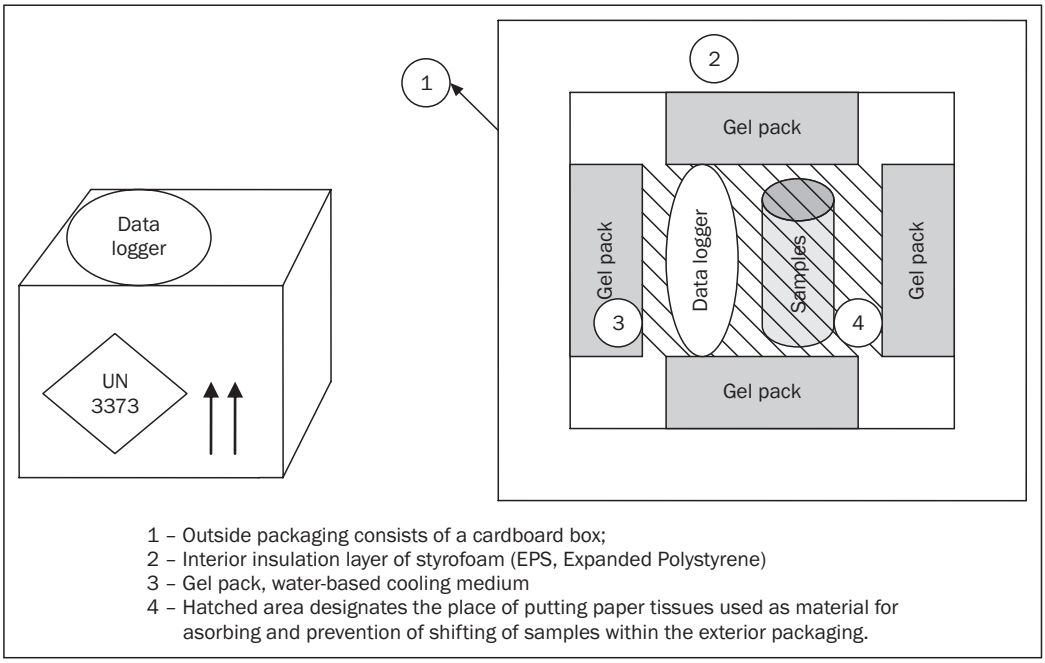

Figure 2 - Positioning of the measuring instruments for every pack

Table 5 - Reference steps in technological process of project realization with recorded temperature

Date and time	Process description and location	Annotation
11.03.2009 11:05	Road transport HZTM – Zagreb Airport	Packing at HZTM location, road transportation to the logistic operator location for documentation issuance and labelling. Road transport to Zagreb Airport
11.03.2009 13:04	Storage at Zagreb Airport Ambient (standard warehouse conditions) and controlled at +2C to +8C	Goods stored as shown in Figure 2
11.03.2009 15:38	Flight Zagreb - Vienna	Different aircraft types used have influence on the temperature profile of the shipment
11.03.2009 16:40	Ramp transfer at transit airport	Goods are transferred from arriving aircraft to the departing one without being processed through the warehouse infrastructure.
11.03.2009 17:30 / A 17:15 / B	Flight A/ Vienna – Brussels and B/ Vienna - London	Different aircraft types used have influence on the temperature profile of the shipment
11-12.03. 2009 17.30 - 10:40/A 17:15 - 09:25/B	Storage at final destination	Goods stored according to Diagram 2
12.03.2009 10:40 / A 09:25 / B	Flight A/ Brussels - Vienna and B/ London - Vienna	Different aircraft types used have influence on the temperature profile of the shipment
12.03.2009 12:35-13:35/A 12:45-13:35/B	Ramp transfer at transit airport	Goods are transferred from arriving aircraft to the departing one without being processed through the warehouse infrastructure.
12.03.2009 13:35	Flight Vienna - Zagreb	Different aircraft types used have influence on the temperature profile of the shipment
12.03.2009 15:30-16:30	Road transport Zagreb Airport – HZTM	Road transport is performed directly from the Airport to the HZTM location
12.03.2009 15:40	Boxes opened, and samples extracted	After extraction under controlled room temperature samples were subjected to testing

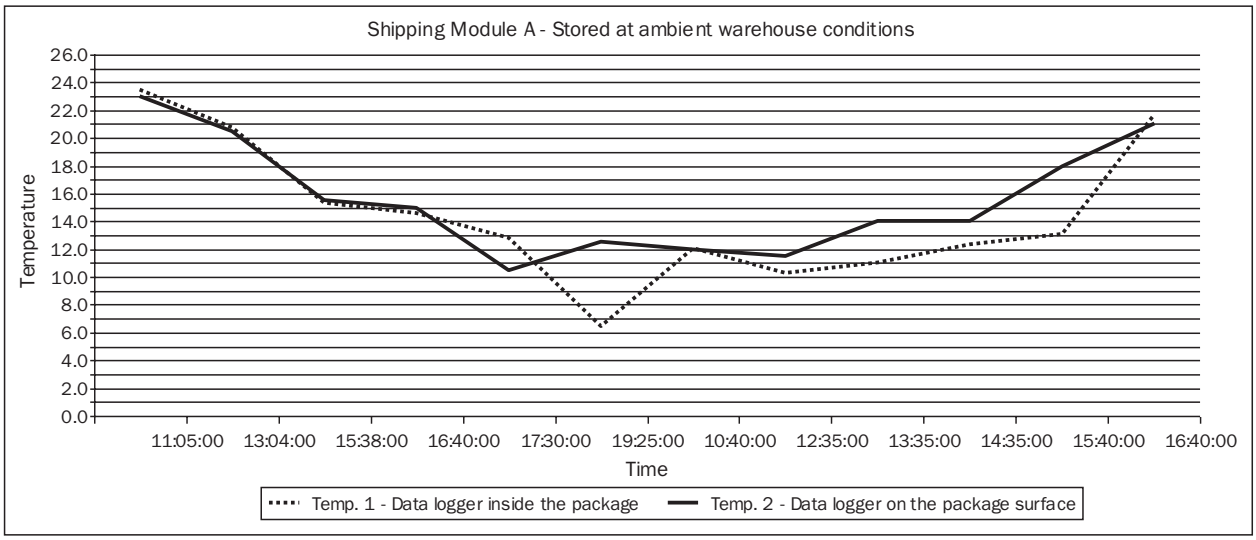

Figure 3 - Temperature profile of transport model A with warehousing in standard warehousing conditions

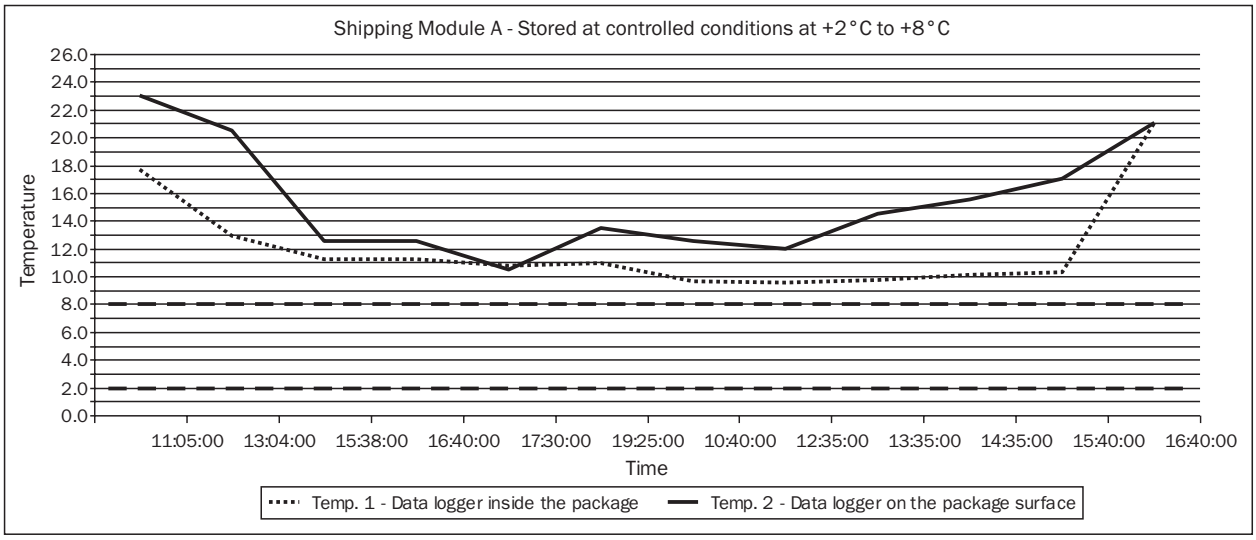

Figure 4 - Temperature profile of transport model A with warehousing in controlled warehousing conditions at +2°C to +8°C

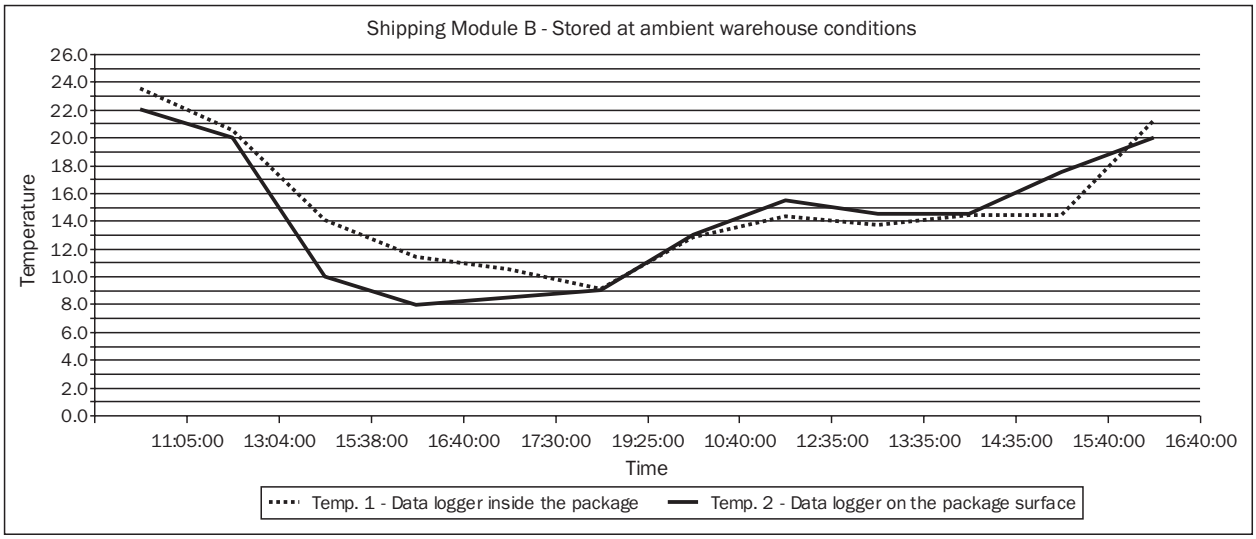

Figure 5 - Temperature profile of transport model B with warehousing in standard warehousing conditions

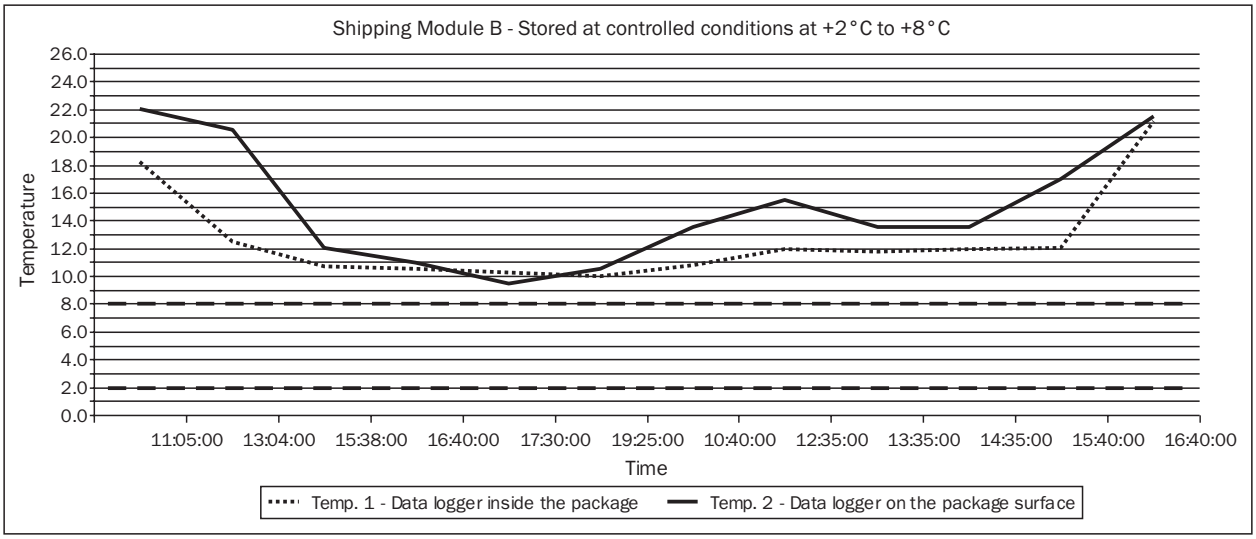

Figure 6 - Temperature profile of transport model B with warehousing in controlled warehousing conditions at +2 °C to +8 °C

regulated in the packaging instructions (*Dangerous Goods Regulations*, *Packing Instruction 650*[24]). Temperature recordings of measurement instruments during transport were considered at 11 reference points. These points in the technological process of transportation may be considered as significant since they are characterized by a high level of interaction of all the included process stakeholders, emphasised significance of responsibility transfer from one stakeholder to another, and the specific environment in which the transport object is found. *Table 5* shows the defined steps as control points in monitoring the recordings of measurement instruments.

Based on the temperature recordings through the mentioned steps, the temperature profile for each transport model was formed. In order to form the temperature profile for the entire year, the recommendation is to make a summer and a winter temperature profile[25]. The concrete case refers to the realisation of the project during the month of March which makes it possible to deduce a conclusion acceptable for the winter profile. *Graph 1* shows the temperature recording during the realisation of the transport task from model A. The temperature requirement for both models in controlled conditions is the transport at a temperature regime ranging from +2 °C to +8 °C (denoted by a green line in Graphs 2 and 4), whereas the non-controlled conditions mean warehousing in standard ambient conditions.

5. CONCLUSION

By analysing the samples before and after the transport in air freight and by comparing them with the control sample stored in HZTM at controlled temperature conditions at +4 °C, considerable changes were noticed on all observed components. The changes presented have been brought directly into context with the conditions to which the samples were subjected during handling and transportation. While observing the efficiency of the packaging designed for this kind of commodity it could be concluded that the application of the cooling elements within the same type of packaging is more efficient in achieving stable temperature regime. At the same time, it could be concluded that the absence of preconditioning of the commodity and packaging could result in the failure to achieve required temperature conditions or +2 °C to +8 °C like in the concrete case. *Figure 3* shows the existence of a temperature extreme with the peak at +6.5 °C. This is an interesting example because it has been recorded within the package which was not equipped with the cooling elements. The reasons for this phenomenon could be found in the fact that the loading position in an aircraft might have an impact on the temperature profile during transportation (loading on positions close to the compartment door could result in lower temperatures). The handling process duration or exposures to environmental conditions as well as the lack of appropriate storage infrastructure might also influence the stability of the temperature regime. Following the gained results after sample analysis it can be concluded that air transportation will have a considerable influence on the blood sample quality. The repetition of the research is thus recommended during summer months when higher atmospheric temperatures are expected having a greater impact on temperatures recorded during the experiment. It could be assumed that higher exposure temperatures might result in more considerable impact on blood sample quality.

ZVONIMIR MAJIĆ, B.Eng.
E-mail: zvonimir.majic@pliva.com
Pliva Croatia, Ltd.
Prilaz baruna Filipovića 25, 10150 Zagreb, Hrvatska
IRENA JUKIĆ, MD
E-mail: irena.jukic@hztm.hr
TOMISLAV VUK, MD
E-mail: tomislav.vuk@hztm.hr
Hrvatski zavod za transfuzijsku medicinu
Petrova 3, HR-10000 Zagreb, Hrvatska
STANISLAV PAVLIN, Ph.D.
E-mail: stanislav.pavlin@fpz.hr
Sveučilište u Zagrebu, Fakultet prometnih znanosti
Vukelićeva 4, 10000 Zagreb, Hrvatska

SAŽETAK

ISTRAŽIVANJE UTJECAJA PRIJEVOZA ZRAKOPLOVOM NA KVALITETU KRVNOG UZORKA

Uzorci krvi su u zračnom prometu klasificirani kao vremenski i temperaturno osjetljivi biološki proizvedeni farmaceutski proizvodi. Kako bi se utvrdila razina utjecaja prihvata, otpreme i prijevoza u zračnom prometu na kvalitetu krvnog uzorka, provodi se istraživanje kroz prijevoz uzoraka na dvije redovne europske zrakoplovne linije. Definirana su dva prijevozna model, standardni za koji nije definiran temperaturni režim prijevoza i prijevoz u kontroliranim uvjetima za koji je zadan odgovarajući temperaturni režim. Krvni uzorci su pakirani i prevezeni uvažavajući svu nacionalnu i međunarodnu regulativu. Provedena je analiza uzoraka usporedbom uzoraka s kontrolnim uzorkom skladištenim u laboratoriju. U usporedbi s kontrolnim uzorkom, zabilježena su značajna odstupanja u svim promatranim komponentama uzorka.

KLJUČNE RIJEČI

regulativa, kvaliteta uzorka krvi, prijevozni model, instrukcija za pakiranje, temperaturni profili

REFERENCES

1. SOP - *Standard Operating Procedure*, Agreement on obligations, conditions and technology of realization in distribution.
2. *Ambient temperature*, a term which in harmonization at a global level changes into *Controlled Room Temperature*, and means temperature regimes in the range from +10 °C to +30 °C.
3. QRT, *Quick Ramp Transfer*, a product of the *Austrian Airlines Company*. It means short transit time at Vienna Airport and direct transfer of the shipment from the arriving to the departing aircraft.
4. *Environmental temperature*, value of ambient temperature of air.
5. EDTA Ethylendiamintetraacetic acid, anticoagulans.
6. Number of erythrocytes measured in vein blood samples immediately after drawing blood expressed in Er x 10E12/L.
7. Number of erythrocytes measured in vein blood samples stored at Croatian Institute for Transfusion Medicine.
8. Number of erythrocytes measured in vein blood samples transported to Brussels in controlled conditions.
9. Number of erythrocytes measured in vein blood samples transported to Brussels in non-controlled conditions.
10. Number of erythrocytes measured in vein blood samples transported to London in controlled conditions.
11. Number of erythrocytes measured in vein blood samples transported to London in non-controlled conditions.
12. Mean value of the presented results
13. Standard deviation – average deviation from the average
14. Calculation of statistical significance compared to measurements made immediately after taking samples
15. Calculation of statistical significance compared with measurements made after storing the samples at HZTM
16. Calculation of statistical significance where the results obtained on the same flight have been compared (non-controlled conditions in relation to controlled conditions of transport)
17. Value of hematocrits expressed in percentages.
18. Total haemoglobin expressed in g/L.
19. Amount of haemoglobin in supernatant expressed in g/L.
20. Percentage of haemolysis in samples.
21. Standardized commercial samples with declared values.
22. Standardized material necessary for measurements
23. *Data logger*, measuring instrument for recording of various data (temperature, humidity, vibrations). In the research the *IMini* model was used, of the manufacturer *Escort Company*.
24. IATA *Dangerous Goods Regulations, 50th Edition, Packing Instruction 650*, instructions for packing of blood samples in air transport.
25. **Bishara, R. H.**, **O'Donnell, K.**: *Developing Temperature Profiles for Medicinal Products in Distribution*, Pharmaceutical & Medical Packaging News, Vol. 15, No. 9, September 2007.

LITERATURE

[1] Republic of Croatia, Ministry of Health and Social Welfare; "*Act on Blood and Blood Components*", Zagreb, June 2006
[2] Republic of Croatia, Ministry of Health and Social Welfare, "*Act on Health Care*", Zagreb, July 2003
[3] Republic of Croatia, Croatian Parliament; "*Act on Medicines*", Zagreb, June 2007
[4] Republic of Croatia, Ministry of Health and Social Welfare; "*Regulations on Clinical Tests and Good Clinical Practice*", November 2007
[5] World Health Organization, *Quality assurance of pharmaceuticals, a compendium of guidelines and related materials*, Volume 2, 2nd updated edition, Good manufacturing practices and inspection, April 2006

[6] World Health Organization, *Good trade and distribution practices for pharmaceutical starting materials*, WHO Technical Report Series No. 917, Annex 2, 2003

[7] **Majić, Z.**, **Pavlin, S.**: "*Problematika tehnološkog procesa transporta određenih kategorija lako pokvarljivih pošiljaka*" (*Problems of the technological process of transporting certain categories of perishable goods*), International Symposium Transport Development Directions, Intelligent transport systems and logistics ZIRP 08, Faculty of Transport and Traffic Sciences, University of Zagreb, Rovinj 16-18 April 2008, e-proceedings, paper No. 19

[8] International Air Transportation Association, *Perishable cargo Regulations* 8th edition, Geneva, Switzerland, July 2008

[9] International Air Transportation Association, *Dangerous Goods Regulations* 50th edition, Geneva, Switzerland, January 2009

[10] **Majić, Z.**, **Pavlin, S.**: *Significant elements of the technological process of transporting biological substances*, 16th International Symposium on Electronics in Transport, Ljubljana, Slovenia, October 2008

[11] **Majić, Z.**, **Pavlin, S.**: *Temperature profiles for carriage of perishable shipments in air transport*, 16th International Symposium on Electronics in Transport, Ljubljana, Slovenia, October 2008

[12] **Bishara, R.**, **O'Donnell, K.**: *Developing Temperature Profiles for Medicinal Products in Distribution*, Pharmaceutical & Medical Packaging News, Vol. 15, No. 9, September 2007