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Comparative Analysis of Cardiopulmonary Markers in Gas Flaring Communities of South-South Nigeria

Ovuakporaye SI[1], Enaohwo MT[2], Odigie OM[1*] and Igweh JC[1]

[1]Faculty of Basic Medical Sciences, Department of Human Physiology, College of Health Sciences, Delta State University, Abraka, Delta State, Nigeria
[2]Faculty of Basic Medical Sciences, Department of Anatomy and Cell Biology, College of Health Sciences, Delta State University, Abraka, Delta State, Nigeria

Abstract

As health implications of frequent and/or inadvertent exposure to poor quality air rises in humans, studies have ranked Nigeria with highest incidences of natural gas flaring across the globe; asserting her to contribute about 46% of overall gas flaring in Africa. With numerous known flaring sites within the country, this study compares markers of cardiovascular and respiratory functions in residents of Oben, Oshi, Ibeno, Ogbia and Agbaro-Otor Communities; common flaring sites within the Niger Delta States of Edo, Rivers, Akwa Ibom, Bayelsa and Delta; south-south Nigeria respectively. A stratified random sampling technique was used to ethically recruit one thousand and eight (1008) participants from across selected communities. Following gender-sorting and obtaining of socio-demographic records (by a questionnaire) of subjects, cardiovascular and respiratory variables (respiratory rates, peak expiratory flow rate, pulse rate, systolic and diastolic blood pressures) were obtained and compared between communities, depending on duration of exposure to gas flaring. With p-value set at .05, one-way analysis of variance (ANOVA) proved that prolonged exposure to gas flaring increased mean blood pressure with a decreased mean peak expiratory flow rate across sampled communities. Gender-dependent variation was also seen to vary across communities, implying that gas flaring impact is gender and duration dependent. Similar, but more sophisticated approach is recommended for other areas in Nigeria with high incidences of gas flaring.

Keywords: Cardio-pulmonary; Gas flaring; Niger Delta

Introduction

Addition of harmful substances to the atmosphere results in damage to the environment, human health, and quality of life. One of many forms of air pollution is gas flaring. Though copious volumes of gases are often flared in commercial scales across petrochemical industries within cities; across continents, in metropolitan areas and even globally; small scale flaring of gas may also be seen in homes, schools, and offices [1,2].

The Niger Delta region, location in Nigeria where largest underground deposits of oil and gas resources are highest is a great example of such an area where flaring activities occur on a regular basis. The area is reputed for petroleum-rich oil, making up 7.5% of Nigeria's landmass. Often pillaged by industrial waste activities of major oil exploration, the region spans 70,000 km^2 (27,000 sq mi) area of land within the southern coast of the country, Nigeria. The effects of oil in fragile communities within the region have been reportedly enormous. According to the government of the federal republic of Nigeria; there were more than 70, 000 oil spills between 1970 and year 2000 with an estimated cleanup expected to span full restoration of creeks, mangroves, aquatic lives and swamps within a 25 years duration [3,4].

Health-wise, one of the adverse effects that may accompany prolonged exposure to flared environmental gases (as seen in the case with Niger Delta) is cardio-vascular and pulmonary abnormalities. Miller reported high incidences of cardio-pulmonary morbidities in pre-disposed subjects within gas flared environs in developing countries [5]. A 2007 study on women predisposed to air pollutants reportedly asserts that prolonged exposures to air pollution are linked with ischemic type of stroke instead of the hemorrhagic type [5]. Polluted air has also been related (by several studies) to increased incidences of coronary and cerebrovascular ailments [6].

Air pollution has been asserted to contain bursts of toxic chemical compounds that may be dangerous and harmful to the human health upon prolonged exposures. Such compounds as but unlimited to hydrogen sulphide (H_2S), carbon di-sulphide (CS_2), benzene, toluene, xylene, styrene, as well as oxides of Sulphur and Nitrogen. Inhalation of H_2S (for instance) in optimal concentration has been linked to spontaneous abortion. CS_2 on the other hand is a known powerful neurotoxin, with volatile aromatic compounds like benzene notorious as a systemic toxicant in humans at any given concentration; with a known potency to cause such health conditions as aplastic anemia, depression and pancytopenia [7]. Benzene, active component of flared gases is a known carcinogen in humans, having the ability to cause leukemia (blood cancer) in a non-mutagenic fashion.

Concerning cardio-respiratory disease, studies have focused on harmful effects of air pollutants on inflammatory blood markers, heart rates, blood pressures and respiratory rates [8]. In a cohort study by Argo, heart rate was shown to increase amongst adults of 25-64 years old during an air pollution episode that monitors the trends and factors of cardiovascular disorders [7]. In another Pilot study by Ubirantan on vehicular traffic controllers, air pollution reportedly increased blood pressures and heart rates within the metropolitan city of Sao Paulo, Brazil [9]. A more recent study by Ativie reported increased cardiovascular and respiratory markers in saw-dust and paint mist polluted air of exposed workers within Enugu Metropolis of Enugu state, south-east Nigeria [10]. Inhalation exposure to cadmium

***Corresponding author:** Odigie OM, Faculty of Basic Medical Sciences, Department of Human Physiology, College of Health Sciences, Delta State University, Abraka, Delta State, Nigeria, Tel: +2347036844454; E-mail: osgiedeprof@yahoo.com

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and its compounds have also been reported to be harmful to oil spill communities and inhabitants upon prolonged exposure [11].

Aim of Study

Study aimed at comparing cardiovascular and respiratory variables in residents of selected communities who have been exposed to gas flaring. Specifically, study accessed Blood Pressures, Heart rates and Respiratory rates; vis-a-vis duration of exposure to gas flaring amongst residents of selected gas flared communities; south-south Nigeria.

Material and Methods

Materials

Data collection was done with the aid of closed questionnaire. An electronic blood pressure kit was used for blood pressure and pulse rate measurements. The peak flow meter (a spirometric device) was used for measurement of peak flow rate. Also used was a timing device (stop watch), a weighing scale (for, measuring participants' weight). Respiratory rate was manually obtained.

Study area

Study covered one community each from five (5) of the Niger Delta States. Each visited communities were over 35 km distant apart, having different socio-economic and cultural backgrounds. In any case, residents within visited communities were essentially artisans, traders, farmers, students and/or civil servants. Edo, Rivers, Akwa Ibom, Bayelsa and Delta were the visited Niger Delta states, with captured towns being Oben, Oshi, Ibeno, Ogbia and Agbaro-Otor respectively.

Study population

Targeted towns had a total population of 51,379 with each being 3,752, 6,600, 4, 252, 6,853 and 4,604 for Oben, Oshi, Ibeno, Ogbia and Agbaro-Otor respectively [12].

Study design

Study was a comparative type that compared residents of selected communities that were exposed to gas flaring study adopted direct administration of questionnaire with observation and recording methods.

Sample and sampling technique

Stratified random sampling technique was used to draw a total of 1008 participants, comprising of 564 and 444 males and females respectively from aforementioned population. Sample size was calculated with the relation;

$$n = \frac{Z^2 \times p(1-p)}{e^2}$$

Where:

n=Sample Size

p=estimated prevalence in sampled areas (0.3)

z=Confidence level at 95% (standard value of 1.96).

e=margin of error at 4% (.04)

(Cochran, 1977)

Selection of Subjects for Participation

Apparently healthy residents of age brackets 12 to 70 years were selected for participation. They were verbally approached with informed consent sought following detailed explanation. Gender-based selection of children was done with consideration of relative proportion of the various age and sex distribution for sampled populace. Random selection was made for children (male and female) within 12-17 years and adults of between 18-70 years. Subjects who smoke tobacco and have stayed beyond a year in sampled communities were excluded from the research. Hypertensives, diabetics, dyslipidemics and atherosclerotic subjects were also exempted from the study.

Procedure

First, socio-demographic data were collected with the aid of closed questionnaire. An electronic blood pressure kit was then used to obtain blood pressure and pulse rates after orally explaining the study to participants. Next, participants' respiratory rates were measured at rest. They were not made aware in order to obtain a reliable count by observing the rise and fall of their chests; the number of respirations per thirty seconds or one full minute. Blood pressure monitoring device (electronic sphygmomanometer was then used to obtain subjects' blood pressures and pulse rates. Next, a peak flow meter was used to check subjects' expiratory flow rates. At any instance, participants were made to repeat steps if not properly done. In each case, procedures were repeated in three times with mean value recorded.

Ethical considerations

Ethical approval was obtained from school heads, parents and community heads were applicable. Accordingly, before commencements of data collection, ethical approval was also obtained from the Bio-Research and Ethics committee of the college of Health Sciences, Delta State University, Abraka, Delta State. Approved consent had registration number; RBC/FBMS/DELSU/14/05.

Statistical analysis

Obtained Data were expressed as Mean ± SD (standard deviation). Differences in mean between variables were calculated with the one-way analysis of variance (ANOVA). Margin of error was valued at .05, and $p<.05$ was considered statistically significant.

Results and Discussions

The tables and figures below show cardio-pulmonary variables as obtained from the field, following prolonged exposure of sampled communities to gas flaring. Refer to the discussion section for detailed explanation of each figure and table as presented here.

Current study was a comparative kind of study that evaluated the impact of gas flaring on selected cardiopulmonary variables of residents of gas glaring communities in selected towns of five (5) Niger Delta States of Edo (Oben), Akwa Ibom (Ibeno), Oshi (Rivers), Ogbia (Bayelsa) and Delta (Agbaro-Otor), southern Nigeria. Studied cardiopulmonary parameters include; Blood Pressure (BP), Pulse Rates (PR), Respiratory Rates (RR) and Peak Expiratory Flow Rates (PEFR). Study also determined these cardiopulmonary parameters for sampled areas across age (Children=12-17 years, Adults=18-70 years) and observed gas faring activity against the duration of exposure of residents in each understudied area; taking standards from residents of gas flared areas within 1-5 years, 6-10 years and greater.

Observations from this study put participants with 1-5 years duration of exposure to flaring at a relatively higher value in almost all measured cardio-pulmonary variables across compared communities. In systolic blood pressure (SBP) for instance, Figure 1 reveals that Ogbia (Bayelsa) with the highest SBP value (155 mmHg) with Agbaro-

Otor (Delta) following next (153 mmHg) in a 1-5 years durational exposure of sampled communities. Comparison also observed Oben (Edo) and Ibeno (Akwa Ibom) with lowest values (118 and 123 mmHg respectively) across sampled towns. Even though these changes occurred within a 1-5 years exposure, tentatively, 6-10 years exposure to flaring saw a lower value (142) for Oshi (Rivers) than those within the 1-5 years range. The implication of this is that flaring activity may be higher in Ogbia (Bayelsa) than any other compared communities within the study. The reason for this high SBP may not be far-fetched; and could be traceable to the increased concentration of flared gases as implicated in Figure 1. This increase in SBP was seen to be statistically significant in adult male upon longer exposure duration. This observation could also be attributed to the physical acute and emotional stress induced by gas flare that may be transient when compared to the more chronic physiological episodic stress induced with SBP [13]. Another possible reason may be the result of exclusion to isolated SBP [14].

On diastolic blood pressure (DBP), study observed a higher DBP value (Figure 2) for 6-10 years exposed inhabitants of Ogbia (Bayelsa) and Oben (Edo) with 96 mmHg and 86 mmHg respectively. Even though >10 years exposed participants had higher values than those between 1-5 years to gas flaring, apparently, Ibeno (Akwa Ibom) and Agbaro-Otor (Delta) showed the lowest DBP mean values (72 mmHg and 78 mmHg respectively) across sampled communities upon comparison. However, this increase in DBP was significantly increased at p<.05. This observation concurs with Egwurugwu et al's report of 2013, wherein they noticed a significant elevation in SBP and DBP among carbon monoxide exposed workers in solid waste industries in Bayelsa, south-south Nigeria [15]. The physiological implication of having highest values SBP and DBP values for Ogbia (Bayelsa) community alone is that, DBP rises as SBP; implicative of increased stroke volume with peripheral venous returns [3,4]; a mechanics that suggests poisoning of the cardiac cycle for residents of Ogbia (Bayelsa) as against others.

Figure 3 compares Pulse rates for participants across sampled communities. Here, mean pulse rate values is seen to be duration dependent with subjects exposed >10 years having values of 92 BPS, 90 BPS and 75 BPS in Ogbia (Bayelsa), Oshi (Rivers) and Ibeno (Akwa Ibom) respectively. However, this value was apparently lower in subjects exposed for 1-5 years than those for 6-10 years; with Oben (Edo) and Agbaro-Otor (Delta) respectively polling 81 BPS and 83 BPS respectively. This statistical decrease (p<.05) cut across gender and age and could also be likened to the excess workload on the heart in its attempt to pump against peripheral resistance due to poisoning. The implication of this is that increased pulse rate may tend towards increased BP6, which is suggestive of hyperactivity of the heart and blood vessels for

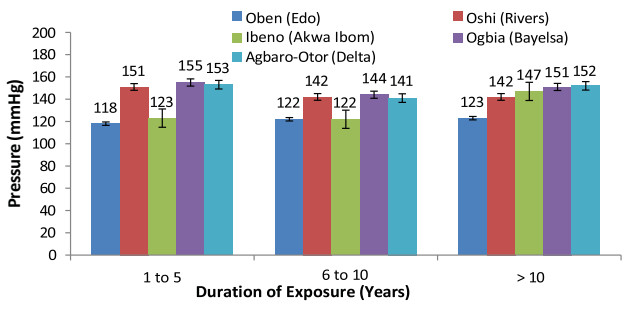

Figure 1: Effect of gas flaring on systolic blood pressures. From above figure, Ogbia (Bayelsa) with the highest SBP value (155 mmHg) with Agbaro-Otor (Delta) following next (153 mmHg) in a 1-5 years durational exposure of sampled communities. Comparison also observed Oben (Edo) and Ibeno (Akwa Ibom) with lowest values (118 and 123 mmHg respectively) across sampled towns.

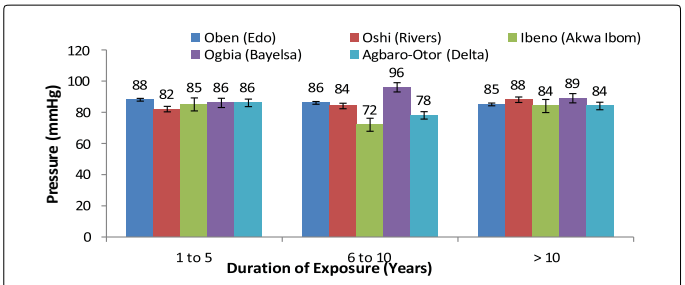

Figure 2: Effect of gas flaring on diastolic blood pressures. Study observed a higher DBP value for 6-10 years exposed inhabitants of Ogbia (Bayelsa) and Oben (Edo) with 96 mmHg and 86 mmHg respectively. This increase in DBP was significantly significant at p<.05.

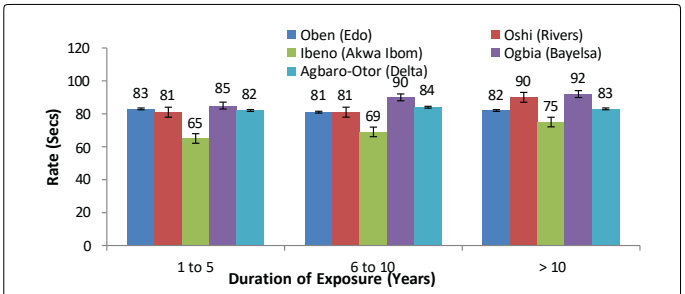

Figure 3: Comparative Effects of Gas Flaring on Pulse Rates. Above figure compares Pulse rates for participants across sampled communities. Here, mean pulse rate values is seen to be duration dependent with subjects exposed >10 years having values of 92 BPS, 90 BPS and 75 BPS in Ogbia (Bayelsa), Oshi (Rivers) and Ibeno (Akwa Ibom) respectively.

residents at such sampled town as compared with others. This finding has further strengthened the reports of Adienbo et al. who observed a significant increase in PR among solid waste workers [16]. The reason for this increase may also be traceable to the physiologic instability resulting from exposure to the chemicals in flared gases. The inhaled particulate matter may decrease oxygen's partial pressure (PO_2) that the body responds to, and thus decrease heart rate. This observation is similar to that of Delvin et al. [17] who documented that exposure to sharp particulate matter is a potent elevator of heart rate, but opposes that of Yeatts et al., [18] that noted a decrease in heart rate variability in association with those exposed to concentrated air pollution, coarse polluted particles, and ambient particulate matter respectively.

Also from current study, comparison of mean respiratory rates for sampled communities (Figure 4) revealed Oshin (Rivers) with the highest value (31 BPS) for subjects exposed to flaring between 6-10 years. Agbaro-Otor (Delta) and Oben (Edo) followed next with 27 BPS, while Ogbia (Bayelsa) had 26 BPS to come last of all duration based exposure to gas flaring. The reason for not having highest values for exposures >10 years (as against what was seen) cannot be really explained. However, perforation-perfusion mismatch resulting from dead spaces during respiration may be responsible for such. Again, loss of functional lungs with age may also account for such [9,10]. Again, comparison between exposures of 1-5 years and those of 10 years and above (Figure 4) implicated Oben (Edo) with a higher mean respiratory rate of 29 BPS, with Ogbia (Bayelsa) following close by 28 BPS. This shows that subjects exposed to gas flaring for as long as 10+ years had higher mean respiratory rates than their 1-5 years exposed counterparts. Also, there was a significant increase in respiratory rate of male and female children as well as resident adults of gas flared communities understudied. This observation agrees with outcome of pilot study by Lina et al. [19] who noticed a breath rate elevation amongst participants

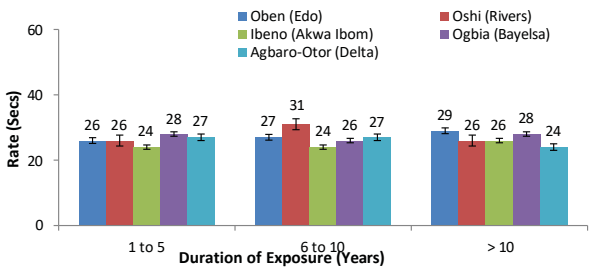

Figure 4: Comparisons of Mean Values of Gas Flaring on Respiratory Rates. Comparison of mean respiratory rates for sampled communities revealed Oshin (Rivers) with the highest value (31 BPS) for subjects exposed to flaring between 6-10 years. Agbaro-Otor (Delta) and Oben (Edo) followed next with 27 BPS, while Ogbia (Bayelsa) had 26 BPS to come last of all duration based exposure to gas flaring.

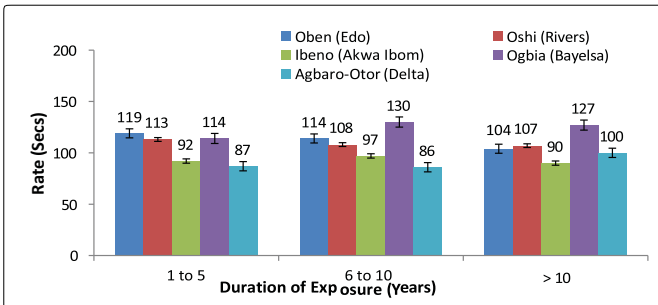

Figure 5: Comparisons of Mean Values of Gas Flaring on Peak Expiratory Flow Rates. Mean peak expiratory flow rates for sampled towns revealed Ogbia (Bayelsa) to have the highest value of 130 BPS and 127 BPS for 6-10 years and >10 years exposure duration to gas flaring upon comparison with 1-5 years of exposure. Agbaro-Otor (Delta) and Ibeno (Akwa Ibom) came lowest in mean PEFR with 86 BPS and 97 BPS respectively, beating participants exposed for as much as 1-5 years to gas flaring within the same community.

Communities	Males					Females				
	SBP	DBP	PR	RR	PEFR	SBP	DBP	PR	RR	PEFR
Oben	184.96	85.52	81.73	29.48	119.04	150.73	85.07	91.66	28.07	104.02
Ibeno	141.9	88.45	90.2	26.35	113.02	148.14	83.43	93.5	29.14	107.09
Oshi	147.77	84.72	75.35	26.64	92.11	149.18	83.36	109	33.63	90.08
Ogbia	151.44	89.72	91.84	28.4	114.02	138.93	84.44	85.96	26.86	127.06
Agbaro-Otor	152.37	84.83	83.45	24.95	87	147	88.61	85.5	27.17	100.01

Table 1: Gender variations in mean values of gas flaring on cardiopulmonary parameters of residents in gas flared communities Edo (Oben), Akwa Ibom (Ibeno), Rivers (Oshi), Bayelsa (Ogbia) and Delta (Agbaro-Otor). From Table 1 above, males from Agbaro-Otor (Delta) are seen to have higher mean SBP values than males of other sampled towns following comparison, with Ogbia (Bayelsa), Oshi (Rivers), Ibeno (Akwa Ibom) and Oben (Edo) respectively having 151.44 mmHg, 147.77 mmHg, 141.90 mmHg and 184.96 mmHg.

in the Beijing Olympics that were exposed to particulate matter, and recorded fast breathe rates as an indicator of poor air quality. Findings from this study however disagrees with those of Adienbo et al. who reported no changes in RR of inhabitants at different gas flared areas at different exposures and duration categories [16].

Again, mean peak expiratory flow rates for sampled towns (Figure 5) revealed Ogbia (Bayelsa) to have the highest value of 130 BPS and 127 BPS for 6-10 years and >10 years exposure duration to gas flaring upon comparison with 1-5 years of exposure. Agbaro-Otor (Delta) and Ibeno (Akwa Ibom) came lowest in mean PEFR with 86 BPS and 97 BPS respectively, beating participants exposed for as much as 1-5 years to gas flaring within the same community. This also suggests a duration-dependent change in the effect of gas flaring on residents of sampled communities. Current study observed a statistically significant decrease in PEFR of children (male and female) who were resident in gas flared communities across the selected towns. Adult male and females also showed significant decrease in mean PEFR values across sampled towns upon comparison (Figure 4). This observation aligns with those of Argo [7], Joffia et al., and Nwafor [12] who reported lower mean PEFR values among people living in gas flared environments as compared with national and international values.

Table 1 shows gender variations in mean values of cardiopulmonary variables on residents of gas flared communities of Edo (Oben), Akwa Ibom (Ibeno), Rivers (Oshi), Bayelsa (Ogbia) and Delta (Agbaro-Otor). Here, males from Agbaro-Otor (Delta) are seen to have higher mean SBP values than males of other sampled towns following comparison, with Ogbia (Bayelsa), Oshi (Rivers), Ibeno (Akwa Ibom) and Oben (Edo) respectively having 151.44 mmHg, 147.77 mmHg, 141.90 mmHg and 184.96 mmHg. The reason for differing SBP amongst males can be traced to differences in gas flaring activities between these towns; which in any case will be responsible for variations in measured parameters (SB DBP PR RR PEFR) between communities. In a similar vein, of the sampled female participants, Table 1 showed SBP and PEFR to be higher in Oben (Edo) with 150 mmHg and 104.04 BPS respectively, with Agbaro-Otor (Delta) having a mean DBP value of 88.61 mmHg to come higher. This gender comparison of parameters also revealed a statistically significant difference ($p<.05$) in males than female counterparts in any case of comparison across communities. Sex hormone differences may be responsible for this difference in obtained cardio-pulmonary variables within male and females of sampled communities.

Importance of study

Study will be relevant in expanding available knowledge on the impact of flared gases beyond its environmental effect. Study will also bring to fore, the cardio-pulmonary effects and changes due to harmful flaring of gas on residents of such environs. It will further arouse interests for scientific and research-based solutions to health implications resulting from oil and gas exploration within the Niger Delta.

Conclusion

Current study has shown a great deal of differences in gas flaring activities across measured cardiopulmonary variables within the Niger-Delta. Importantly, the study revealed Ogbia (Bayelsa) as highest in most of the assayed cardiovascular parameters (SBP, DBP and PR), with Ibeno (Akwa Ibom) and Agbaro-Otor (Delta) following in PEFR and Respiratory rates. The implication of this is that, gas flaring activities is tentatively higher, and the devastating effect as such on the cardio-pulmonary variables are apparently seen as such within residents of the highly flared gas communities as seen from this study.

Gender-dependent differences were also observed as such, with female participants, having SBP and PEFR to be higher in Oben (Edo) with 150 mmHg and 104.04 BPS respectively, while those (females) in Agbaro-Otor (Delta) had mean DBP value of 88.61 mmHg to come higher. Resident males from Agbaro-Otor (Delta) were also seen to have higher mean SBP values than males of other sampled towns upon comparison.

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